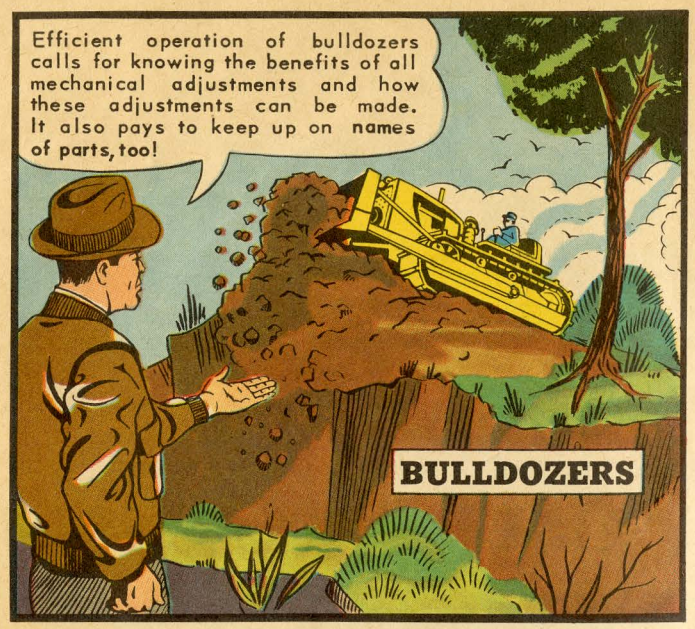
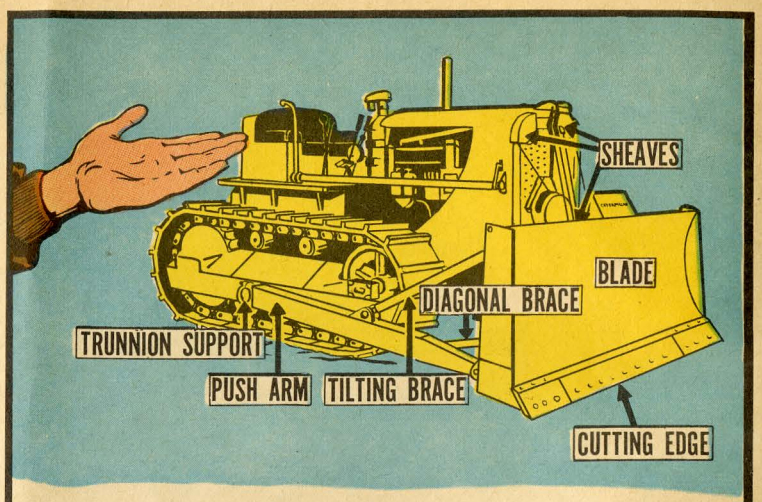
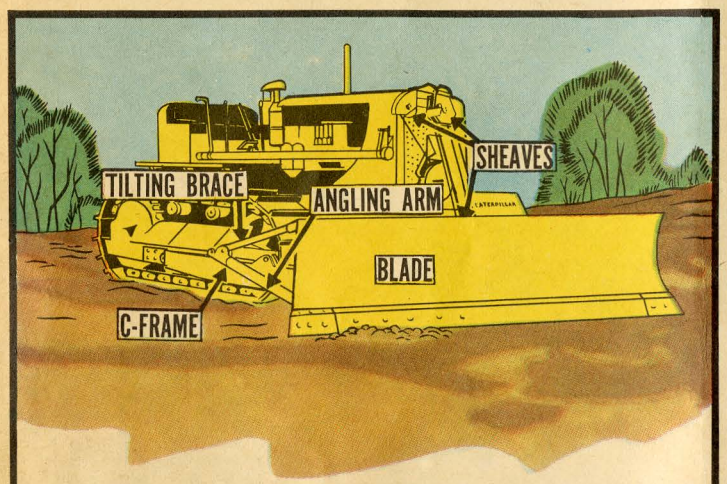
Here's a booklet prepared especially for equipment operators. It contains information on the operation of bulldozers, scrapers, rippers and cable controls, plus additional material on tires and grade stakes. Many of the techniques shown here were worked out by operators like yourselves and will be familiar to you. We hope that the material in this booklet will prove both interesting and helpful.
OPERATOR'S HANDBOOK
CATERPILLAR, Peoria, Illinois

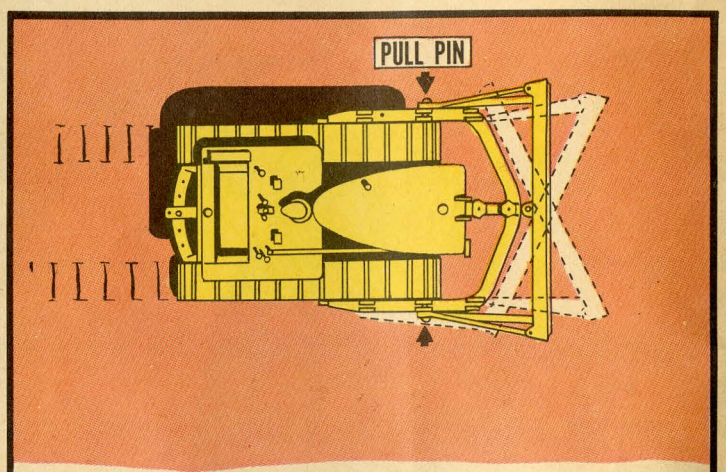




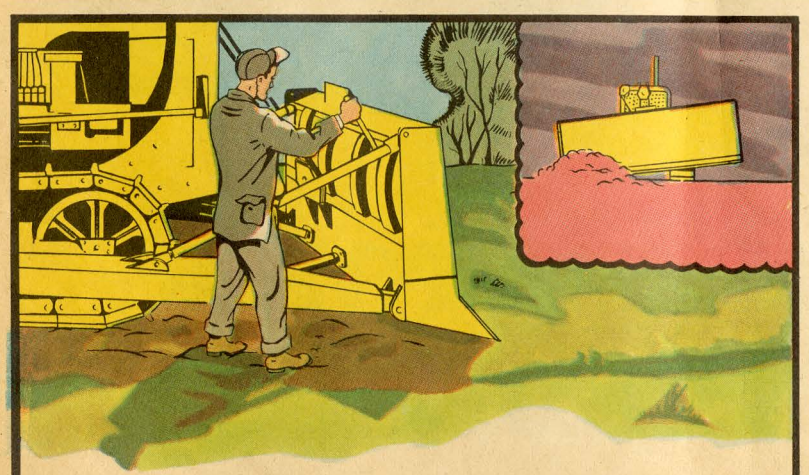
For example....here's the straight blade bulldozer with important parts indicated.



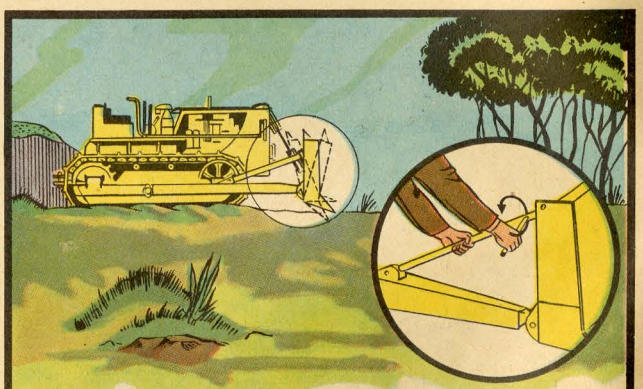
....and here's an angling blade bulldozer with blade angled 25°. Remember these terms....a real operator knows his unit backwards and forwards.



Angling type 'dozers can be adjusted to drift material to either side by simply pulling a pin on both sides and then repositioning blade.



For digging next to hillsides or for penetration in hard ground, well designed bulldozers can be tilted by turning the tilting brace on each side in opposite directions.



On all units, except angling type bulldozers, blades can also be tipped forward or backwards to match ground conditions. Tip blade by turning both braces in the same direction. Tipping also exposes a new edge on the cutting bit; therefore, it's a good idea to tip the blade periodically for maximum production.

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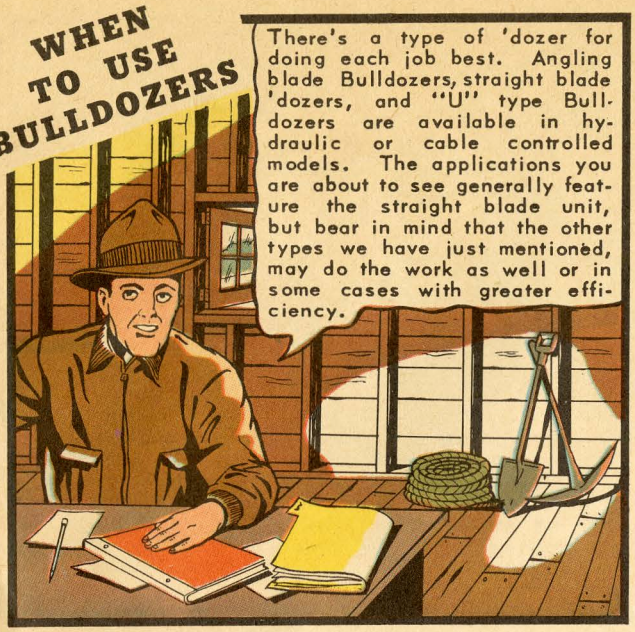
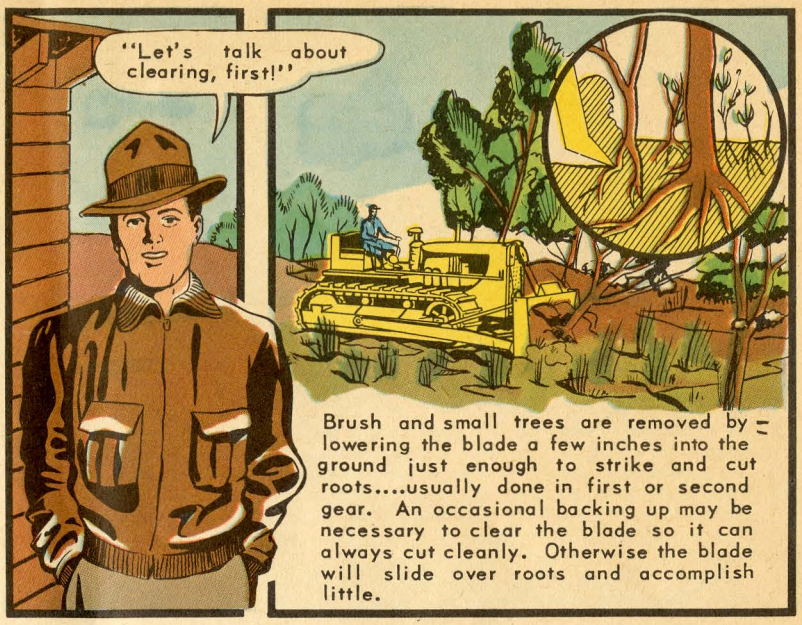
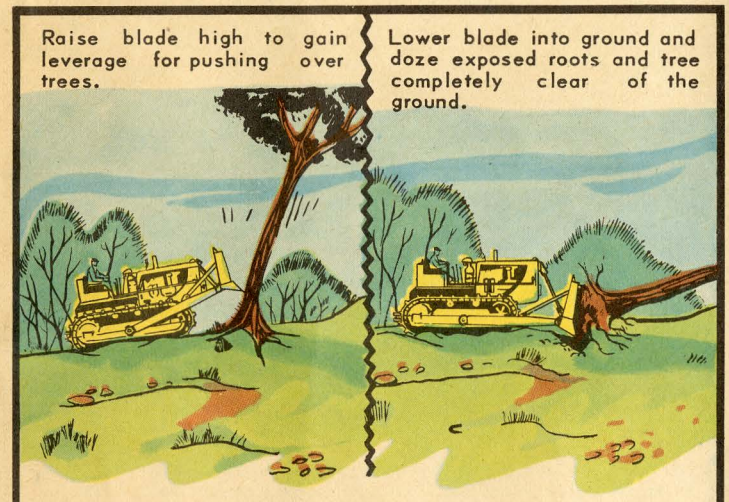
WHEN TO USE BULLDOZERS

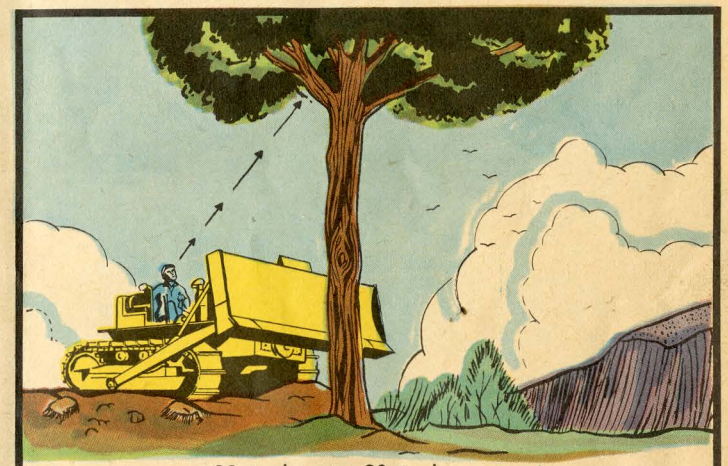




Brush and small trees are removed by lowering the blade a few inches into the ground just enough to strike and cut roots....usually done in first or second gear. An occasional backing up may be necessary to clear the blade so it can always cut cleanly. Otherwise the blade will slide over roots and accomplish little.

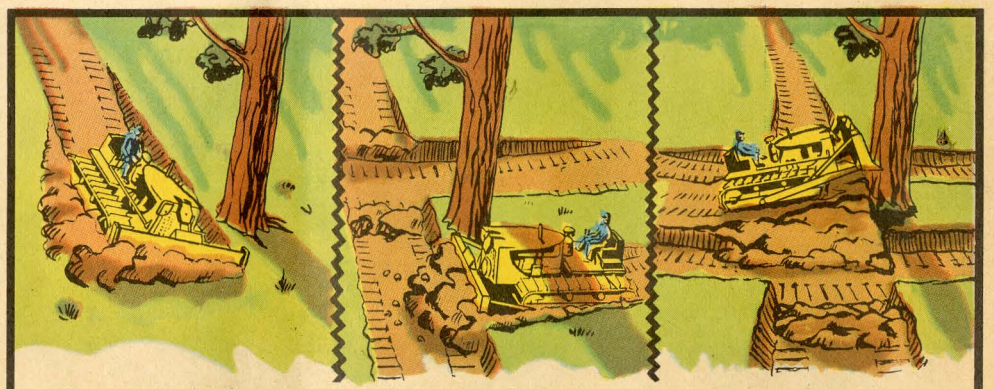


Bigger trees and brush....4 to 10 inches in diameter usually require more than one pass. About 1 to 3 minutes are required to do this operation.



Large trees - 12 inches to 30 inches...require more care and time to uproot. First contact tree with blade high and centered for maximum leverage. Make contact gently...push a few times at half throttle while watching the top carefully. Look for dead limbs - they're widow makers! If tree seems in good condition open the throttle and try again.

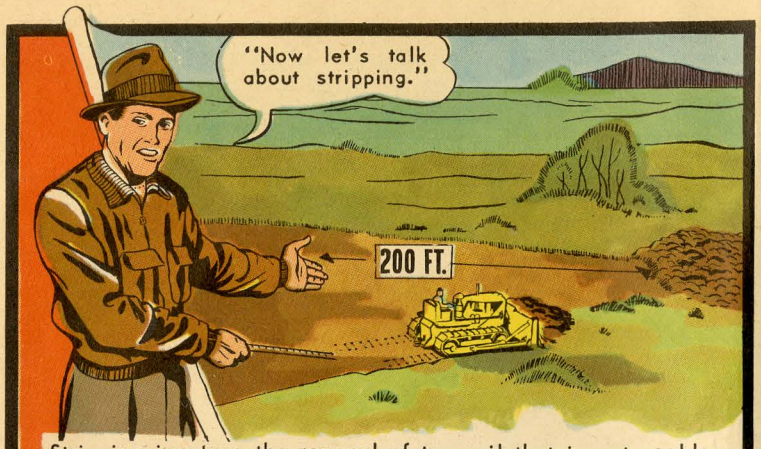
DON'T charge into big trees at full throttle. It's a real "widow maker" technique. And don't push too long at a time. Track spinning is wasted effort.



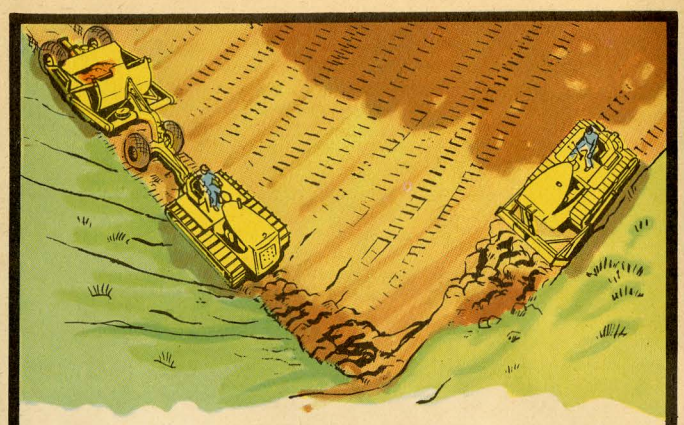
To remove the larger trees follow a 3 step procedure: First, determine the direction of fall....usually in the direction of lean....and then make a few passes on the opposite side to a depth of say, 2 feet, or enough to cut some of the larger roots.

Second, cut roots on both adjacent sides in a similar manner.

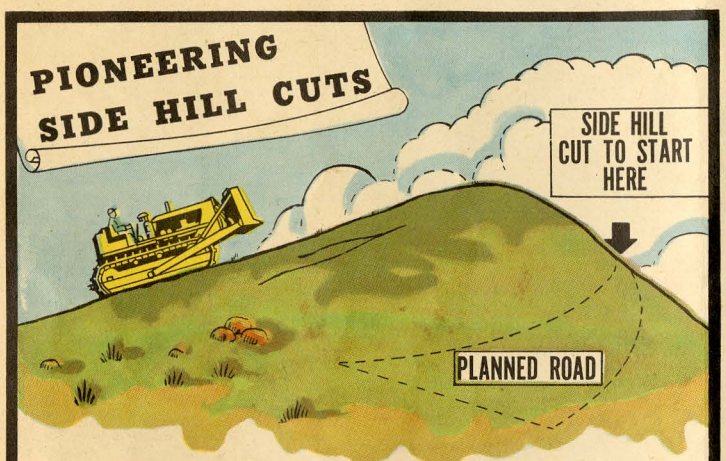
Build an earth ramp up to the starting side of the tree to get still more leverage and then push. As the tree starts over, reverse tractor quickly, for the roots pulling out of the ground may damage the machine. Next fill stump hole and then lift entire root section clear of the ground. Approximate time for such an operation may run from 5 to 20 minutes.



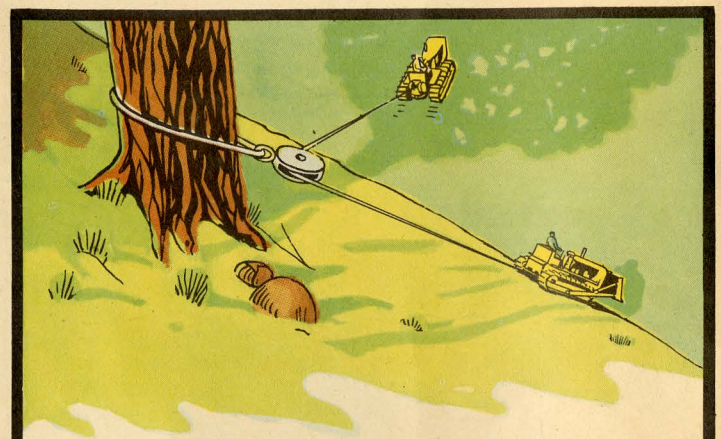
Stripping involves the removal of top soil that is not usable as fill material in a stabilized sub-grade. This material may also be piled somewhere for later use in seeding or sodding. Principal problem is the spotting of stockpiles or waste areas so that you do not "doze" over too great a distance.... usually about 200 feet. Try to handle each load only once for maximum economy.



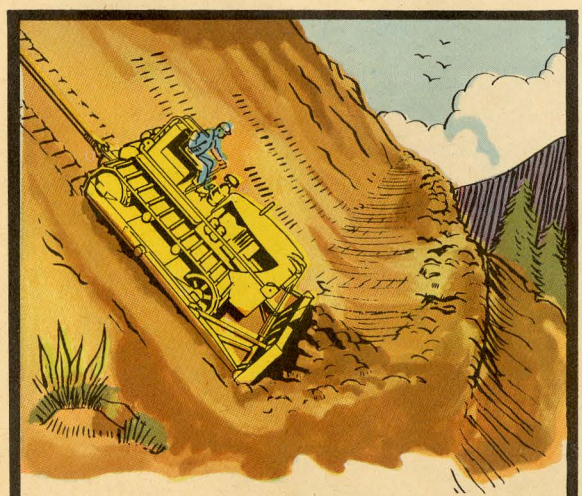
In rough or steep terrain where hill sides and narrow ravines must be stripped, hauls are usually long. It's a good idea to feed top soil downgrade to scrapers which work in the open and at low cost on longer hauls. Always plan all stripping operations so other earthmoving units can begin excavation as quickly as possible.



Always start or pioneer all side hill cuts from the top of hills and then work your way down with the cut. It may be necessary to reach the starting point by climbing up a more gradual slope on the opposite side of the hill. **Working downhill gives you the advantage of gravity.**



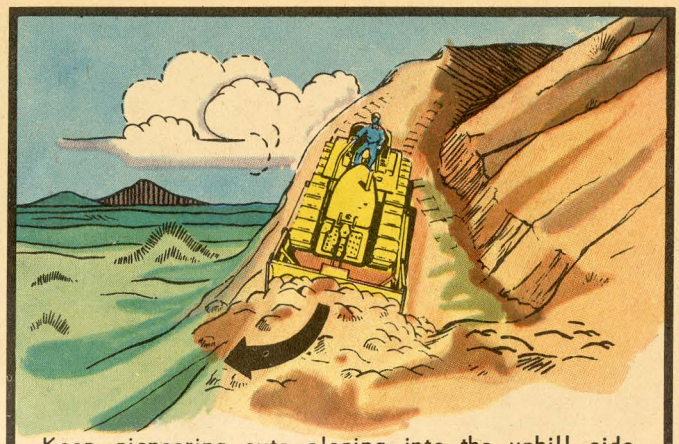
On many jobs a little "roughing out" will enable the 'dozer to make its way up the hill. On others, when terrain is exceptionally steep and rocky, hang a block and tackle on a tree or anchor point and use another tractor to pull the original machine up the hill. If the pioneering tractor has a suitable winch it can pull itself up.



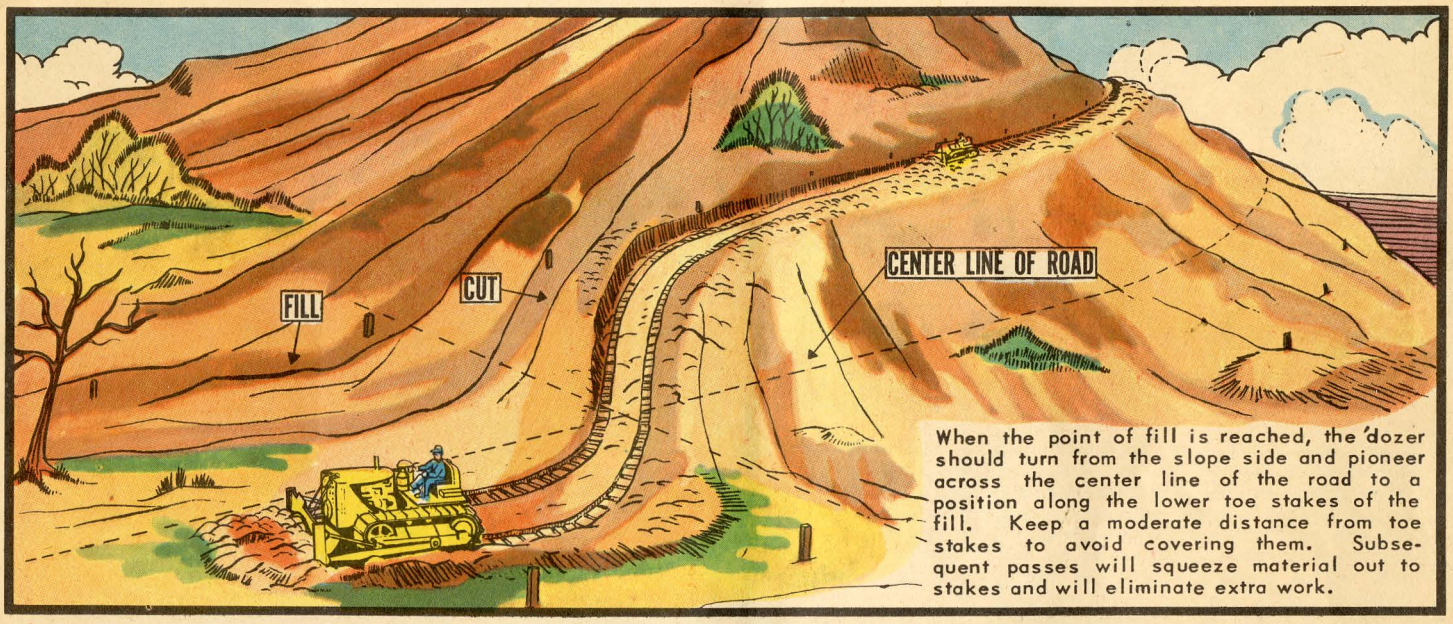
Work very steep areas by hanging on the line until a bench is well started.

On average terrain start cuts working straight down the hill making short passes to bench out an area large enough so that the tractor can eventually turn and work parallel to the road.

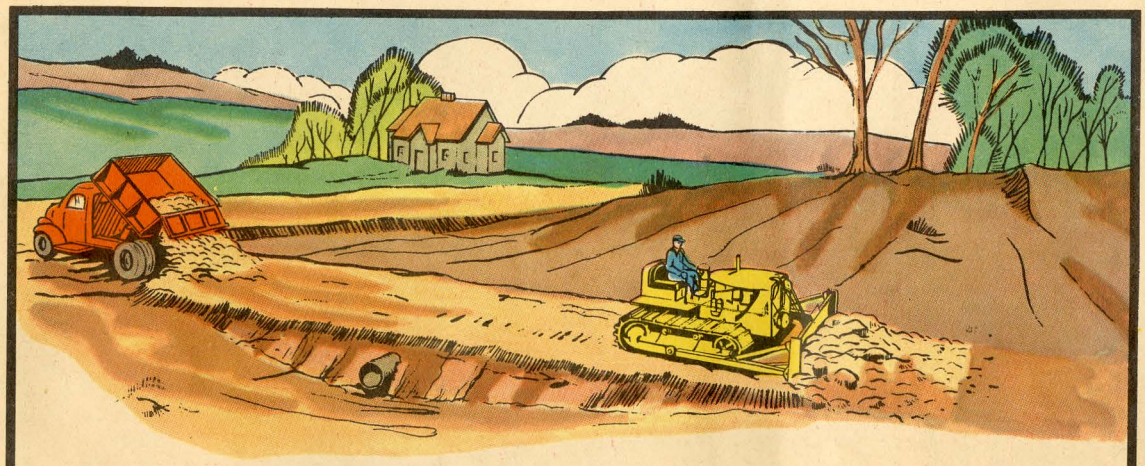
Begin all pioneering cuts within an inch or two of the upper slope stakes to start the job properly. If this is not done, material on the back slope will have to be removed later at a considerable cost.



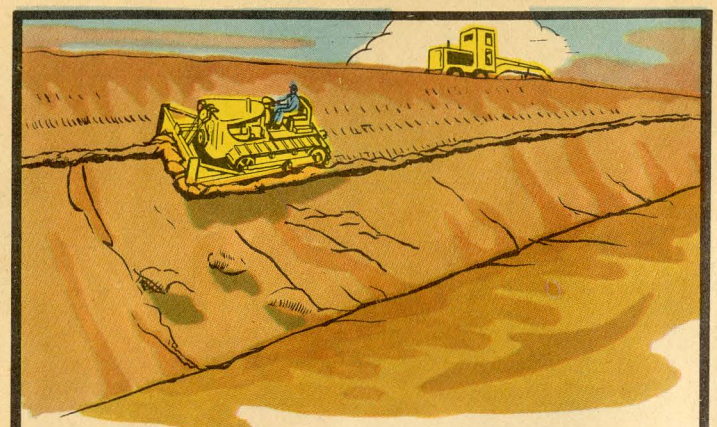
Keep pioneering cuts sloping into the uphill side for maximum earthmoving efficiency. Make short swinging passes as you work downhill to drift material over the side of the cut. Make pioneering cuts wide enough so that scrapers following will have their rear wheels on solid footing. Otherwise scrapers will have a tendency to tip away from the backslope.



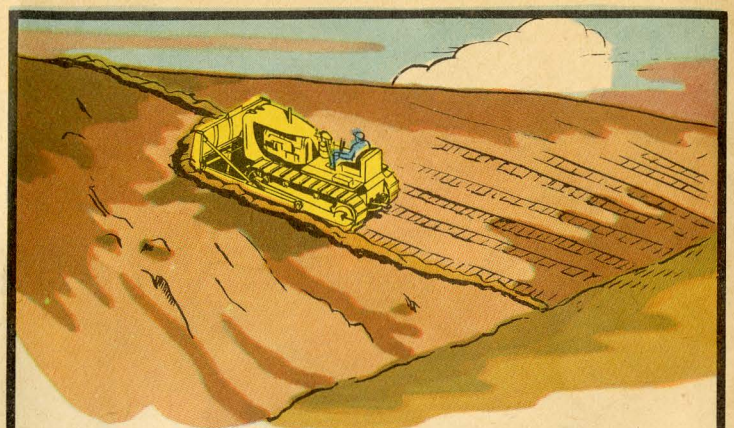
When the point of fill is reached, the 'dozer should turn from the slope side and pioneer across the center line of the road to a position along the lower toe stakes of the fill. Keep a moderate distance from toe stakes to avoid covering them. Subsequent passes will squeeze material out to stakes and will eliminate extra work.



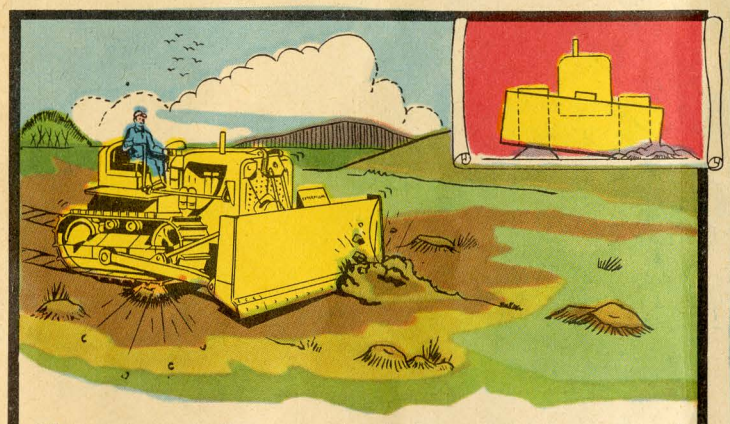
When trucks or wagons are used for hauling, bulldozers are ideal spreading tools at the fill. Blade should be kept in a straight position so that material is drifted directly under the cutting edge. Depth of a spread is usually set up in the job specifications to obtain desired compaction.



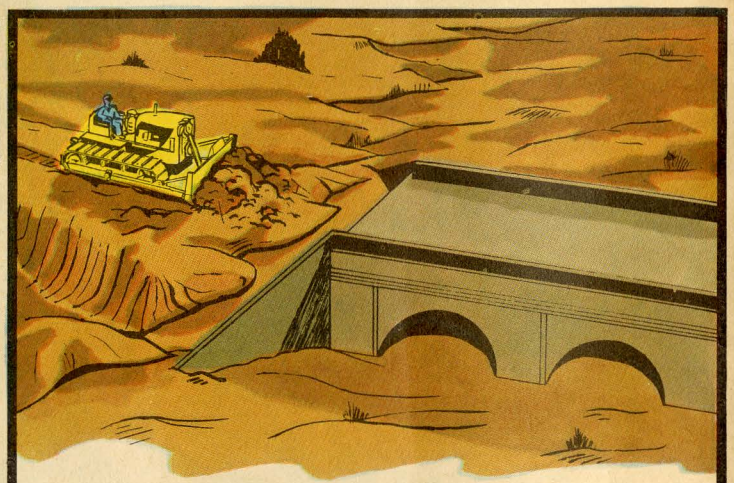
Side slopes can be finished with a 'dozer by starting at the top and travelling parallel to the right-of-way. Earth from each pass will fall to the lower side of the blade and form a windrow. This material is then picked up on succeeding passes filling up irregularities in terrain. Don't allow blade corner to dig as the slope will steepen beyond job specifications.



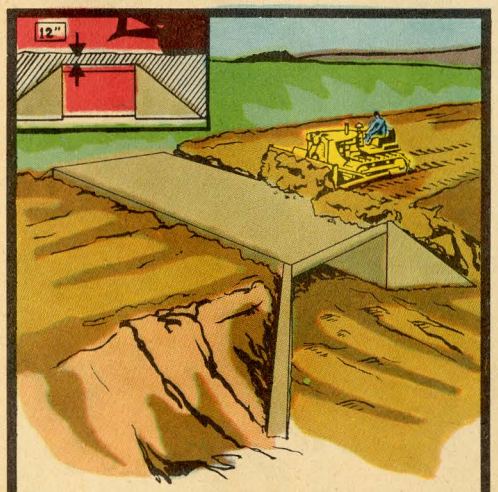
Another method commonly used. Start at the bottom and travel diagonally up the slope. In this way a windrow will be continually drifted to one side and will tend to fill low spots or irregularities.



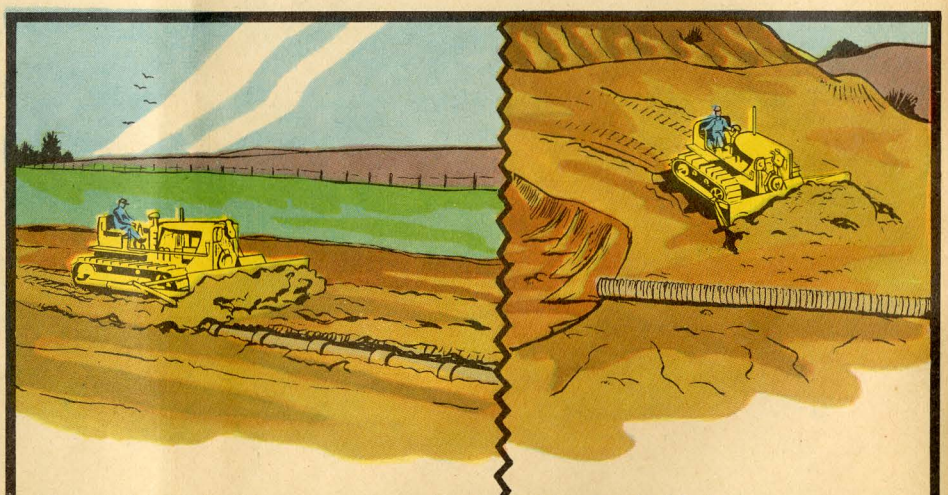
When using a bulldozer to finish, be sure tracks are level before dropping the blade. Otherwise the blade will bite in when it shouldn't. Remember that the blade tends to follow any up or down movement of the track frames. Do not attempt to finish closer than one or two tenths of a foot as this phase can usually be handled more efficiently with motor graders. 'Dozers are production units, not finishing tools.



Backfilling is the placement of earth against buildings, abutments, drainage pipes, or the filling of trenches or ditches. Maneuverability of 'dozers make them ideal for this type of work.

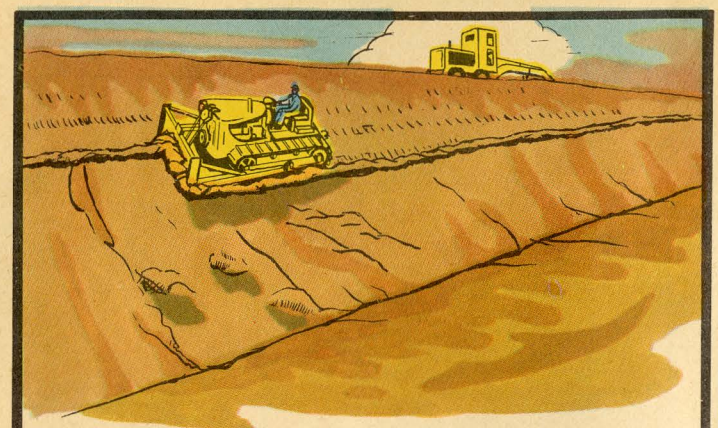


Don't cross culvert with tractor unless there are 12 inches of solid material on top.



Angling blade bulldozers are excellent for backfilling ditches as they can drift material into the trench while maintaining forward motion.

With straight blade 'dozers approach at an angle and end up each pass by swinging into the structure or culvert for smooth, fast results.



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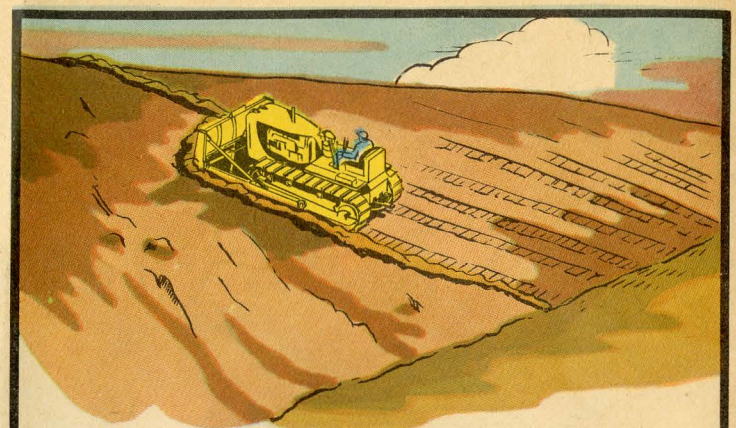

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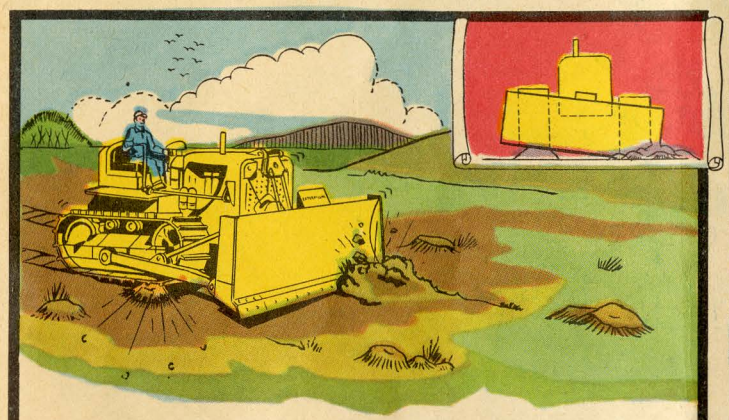

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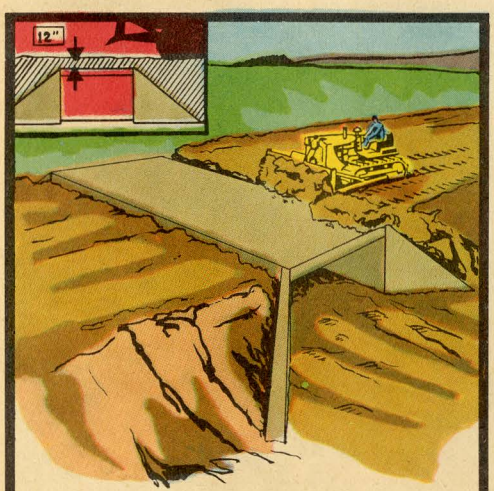

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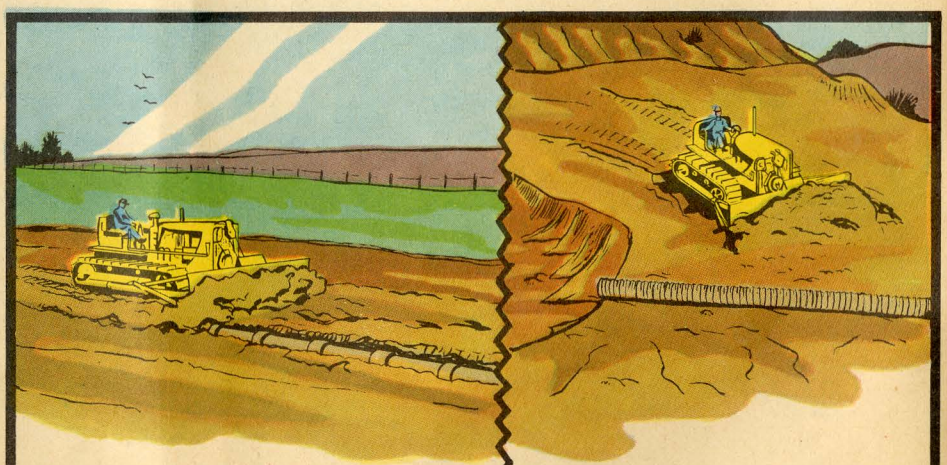

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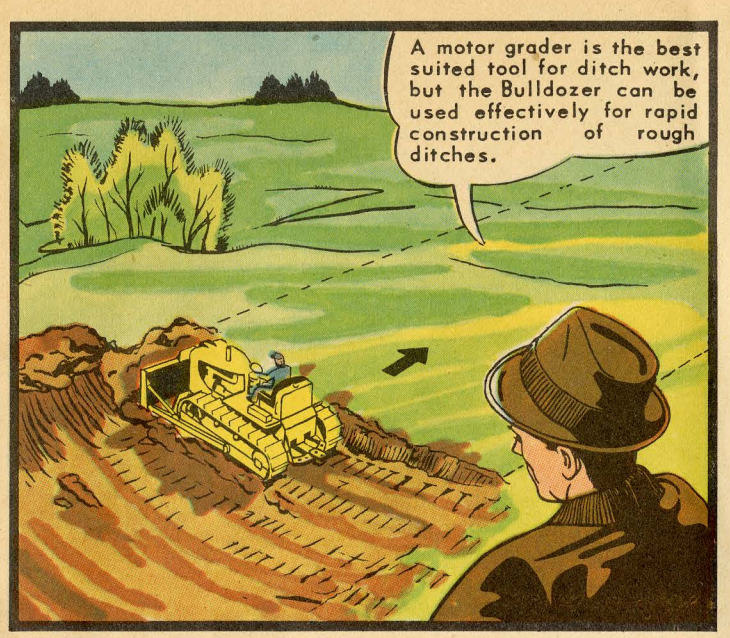
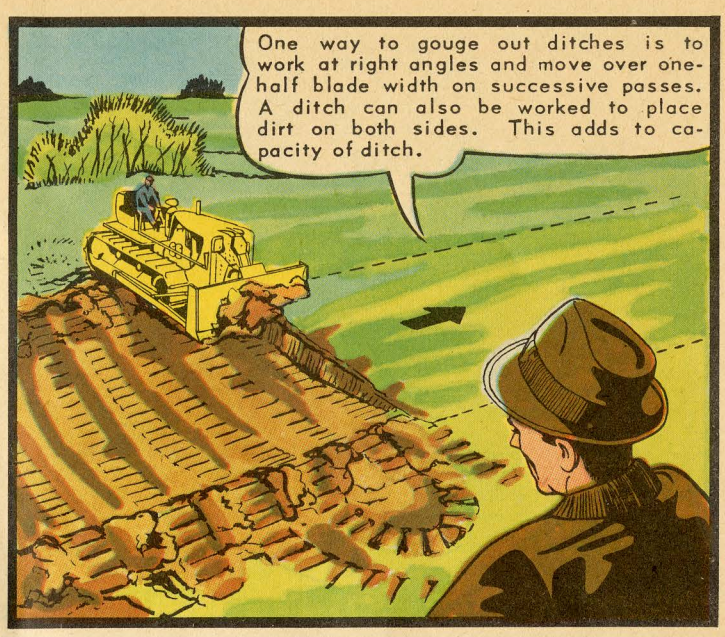
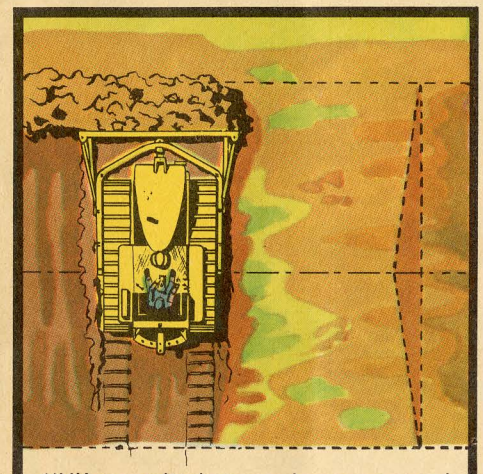
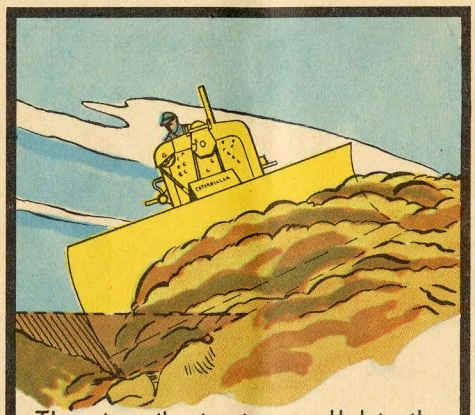


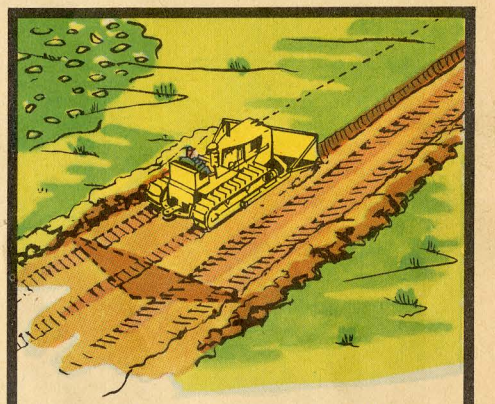




"V" type ditches can be constructed quickly by first building up a ramp just inside the edge of the proposed ditch. This is done only for the first 20 feet of ditch.

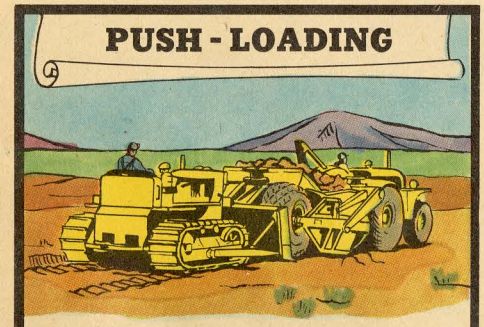


Then turn the tractor parallel to the ditch and place one track on this ramp. Blade is now automatically in position to groove out one side of the "V". An angling type blade is ideal, of course, for this kind of a job as it can cast material to the outside of the ditch line as it moves along.

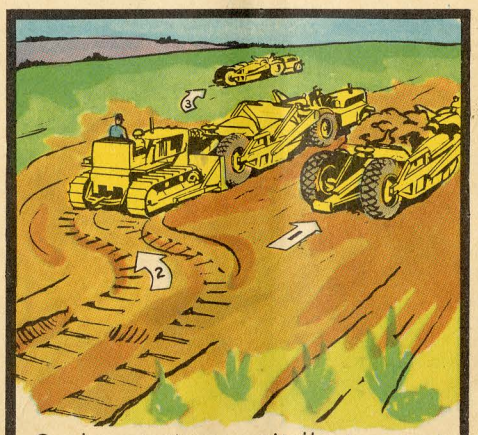


Repeat this entire procedure for opposite half of the ditch and the result is an excellent ditch. Well designed 'dozers are equipped with a tilting arrangement which enables one corner of the blade to be lowered. Such a design eliminates the need for building temporary earth ramps to get blade into a tilt position.

PUSH-LOADING



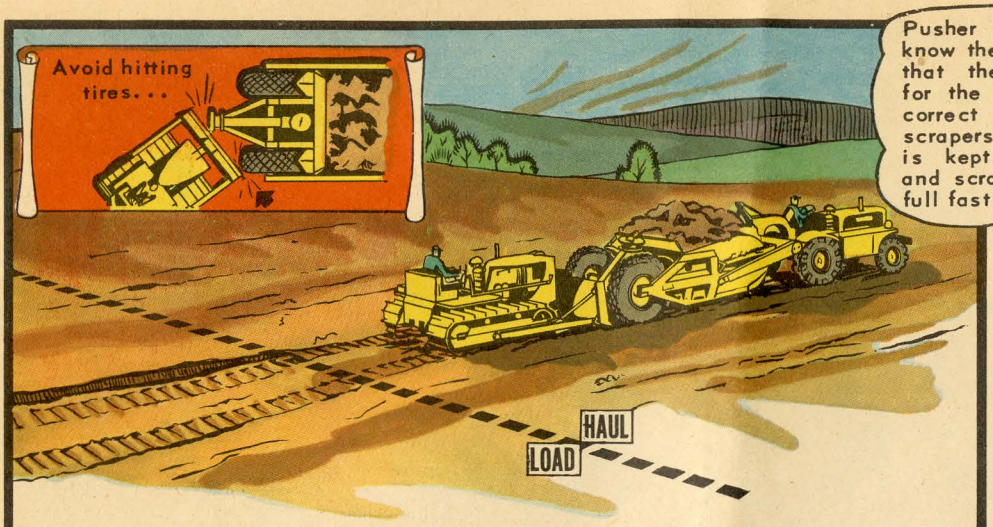
Dozers are excellent units for push-loading scrapers in the cut. Generally push-loading is used to heap up extra large scrapers. Also used for average size scrapers working in hard material or when a decrease in loading time means extra production. And, of course, wheel type tractors pulling scrapers are also designed for push-loading as speed on the haul and not traction is a prime consideration.



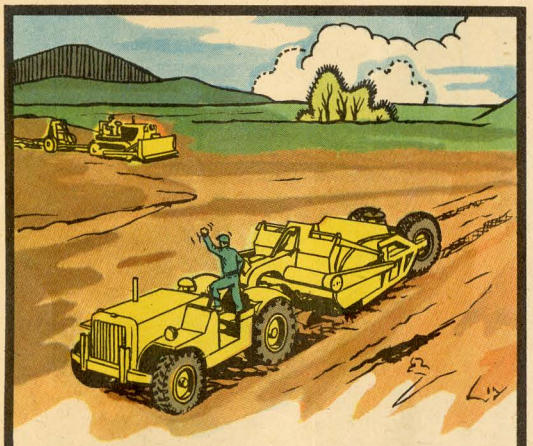
Good operation is vitally important in push-loading as profits can be made or lost in the cut. "Chain load" wherever possible to eliminate delay in switching from one scraper to another. Remember a competent man on a pusher unit, affects the production of more than one scraper.

HERE ARE A FEW HINTS

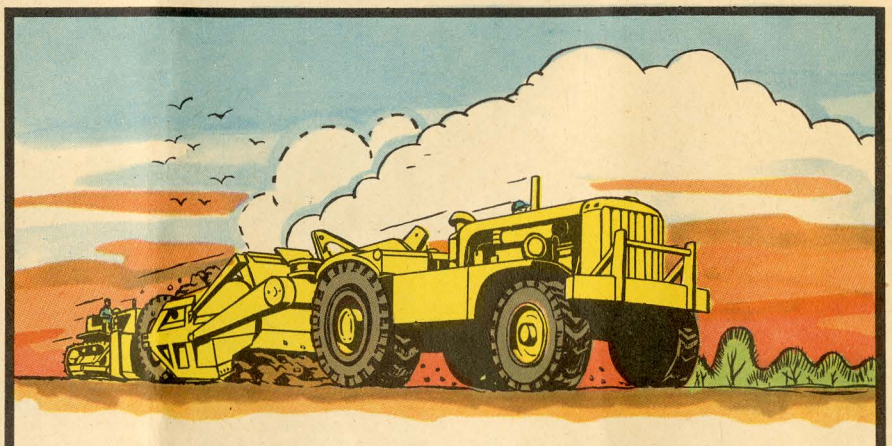
Always contact scraper and push in a "straight-line" manner using full power on both tracks. If scraper and pull tractor are at an angle with pusher, jacknifing will occur causing small loads and longer loading times. It pays to straighten out before continuing loading.



Continue pushing after a full load is gained so pull tractor operator can shift to a higher gear for a quick get-a-way and more production. In sandy or soft footing this extra push really pays off and saves machine maintenance.

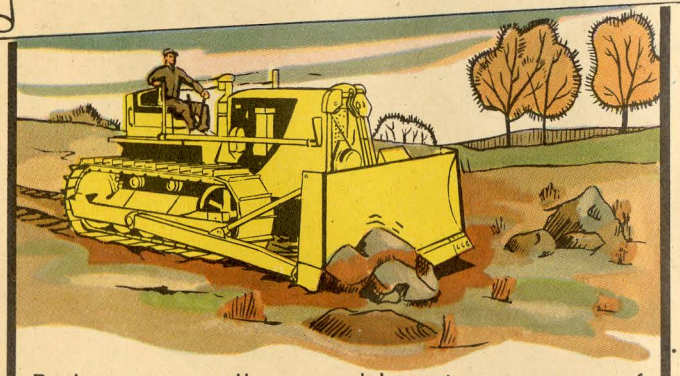


When pusher tractor is equipped with a ripper always remember that the primary responsibility is to load scrapers. Rippers are a good investment for faster loading, but do your ripping and house cleaning when no scrapers are around.

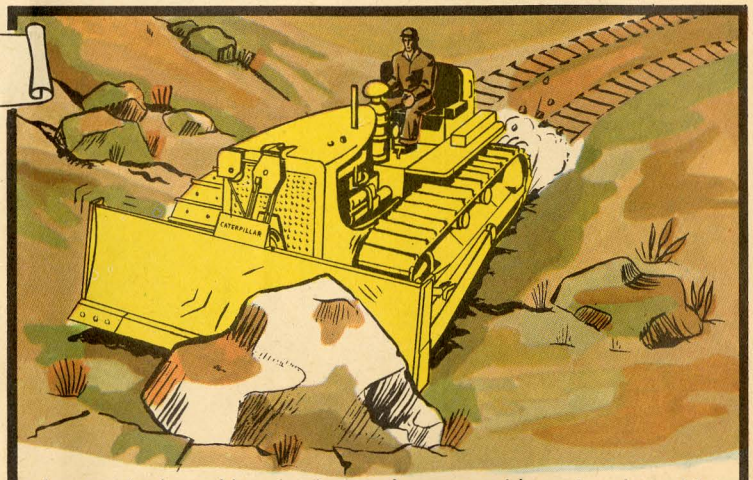


In loose or sandy material try loading with both tractors in second gear instead of low gear. While in low gear and poor tractive conditions exist, excessive slippage may result.

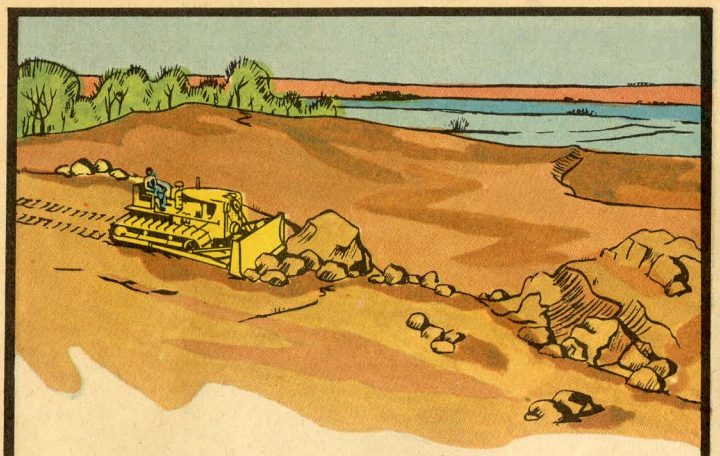
ROCKS AND FROZEN GROUND



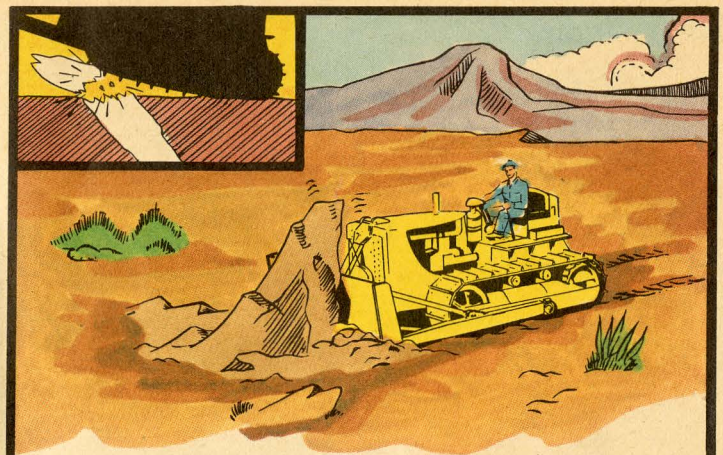
Rocks are generally removed by using one corner of the blade as this allows full power of the tractor to be applied on a short section of the blade. It's a good idea to tilt one corner for better penetration.



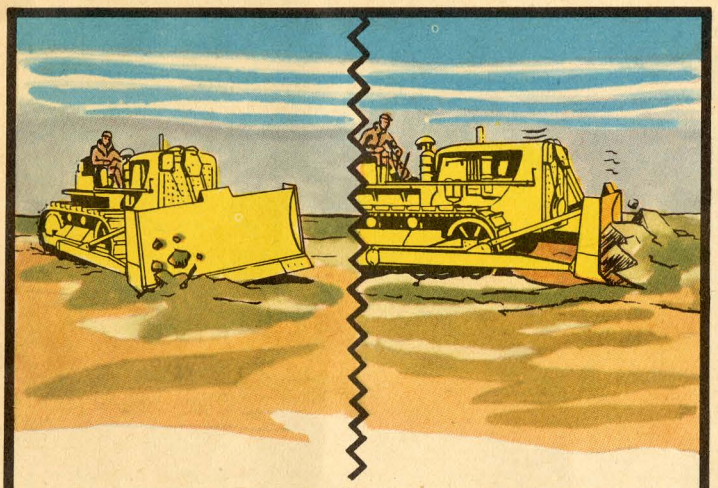
Large single stubborn rocks can be removed by using the cable control for lift and disengaging the steering clutch on the side furthest from the rock. This allows tractor to move forward and crowd the rock without stalling engine. Powerful blade action will lift the rock free.



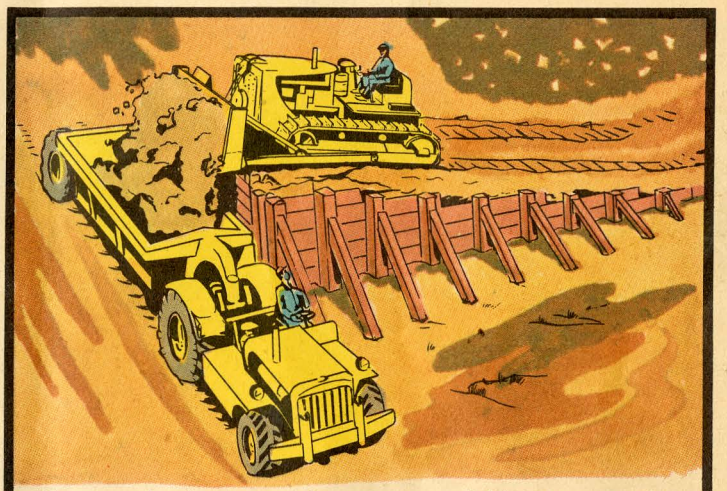
When a large rock is imbedded in a group of smaller ones, loosen and remove the smaller ones before attacking the big one. Operators should remember that if a rock doesn't move, something is holding it. Before proceeding, find cause and remedy it to prevent machine damage.



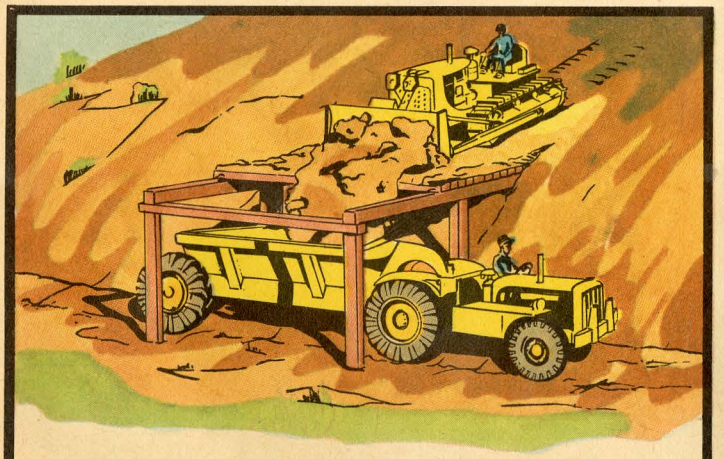
Many rocks such as shale and sandstone are found in tipped position. Always dig under the outcrop, lift, and break it out rather than try to penetrate from the opposite side. Sometimes driving a tractor on top will crush such rocks making removal easy.



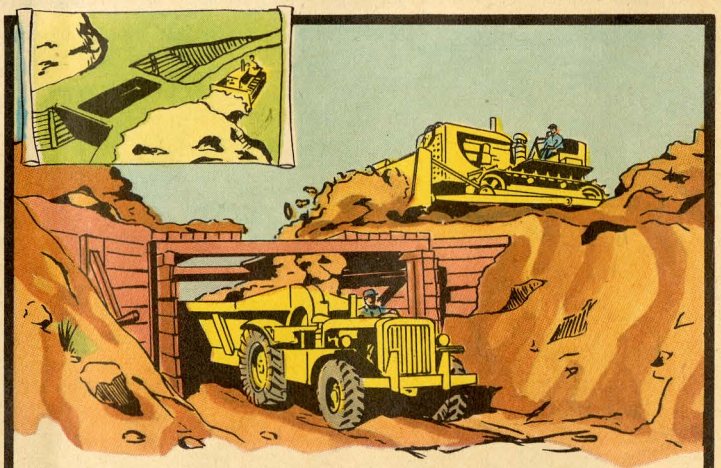
On frozen ground penetrate through the crust by tilting one corner of the blade. Once an area is penetrated it's a simple matter to work against the exposed edge by pushing and lifting.



When regular loading tools are not available it is possible to utilize bulldozers for filling trucks and trailers. Inclined ramps, built of earth, steel or wood, are a means to assist loading economically when level terrain predominates.

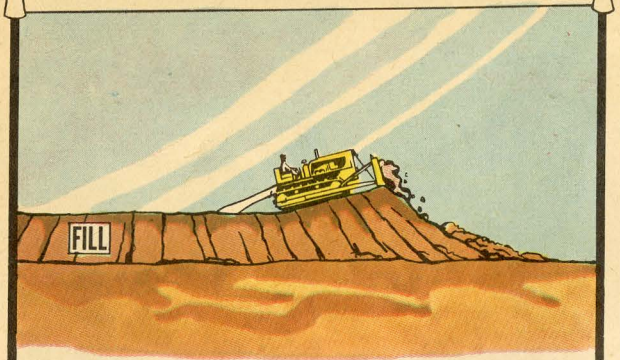


In hilly countryside another type of ramp or grizzly can be constructed for quick loading. Spread a layer of earth on the ramp to minimize wear on planking. Be sure these structures are strong enough to support weight of tractor and load.

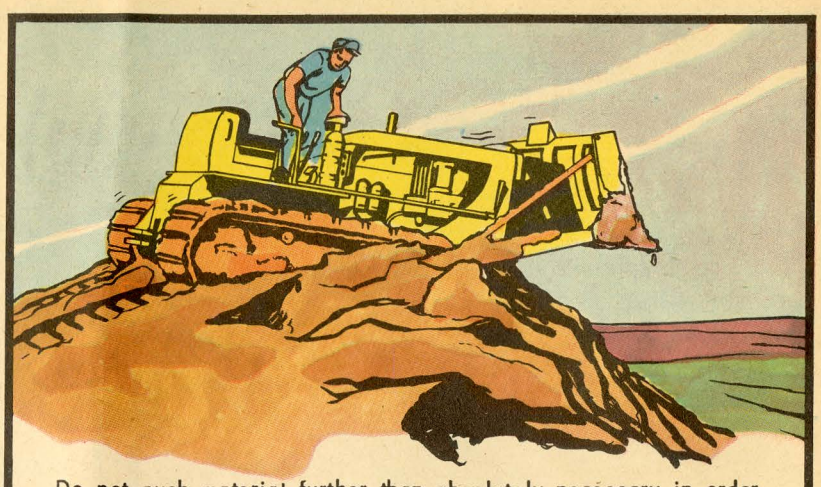


Another way of loading is to excavate a vertical-bank trench to a depth suitable for truck use. It's a good safety measure to sheath the earth sides of this trench to avoid cave-ins. Hauling units tend to come in bunches, so always have a stock pile of material near by for instant use.

WORKING ON SOFT FILLS

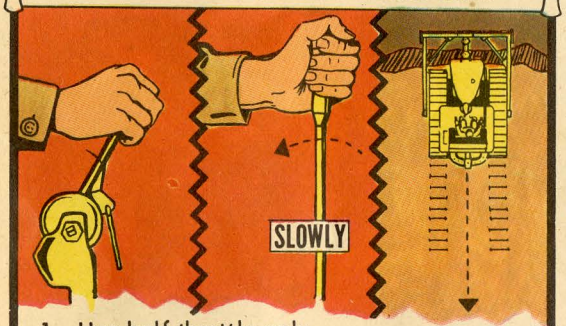


When earth is brought to soft fills with trailers or trucks, 'dozers are generally used for leveling and spilling material over the end. Always keep the fill end high as the tractor will mire less if it can back up going down grade.

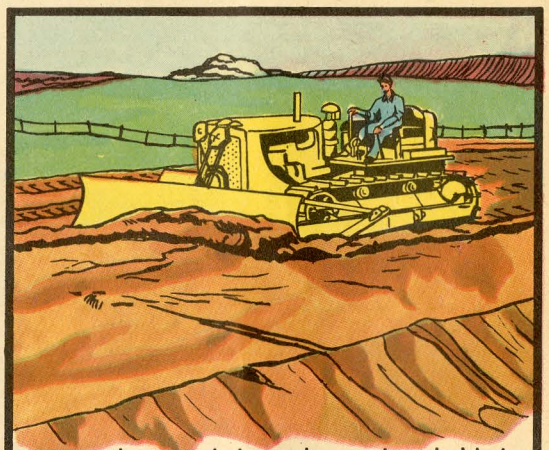


Do not push material further than absolutely necessary in order to stay on firm footing. When backing up, do not raise blade as illustrated here. Raising the blade puts extra weight on the front idlers causing greater track penetration. Let blade float as you back away from the edge of soft fills.

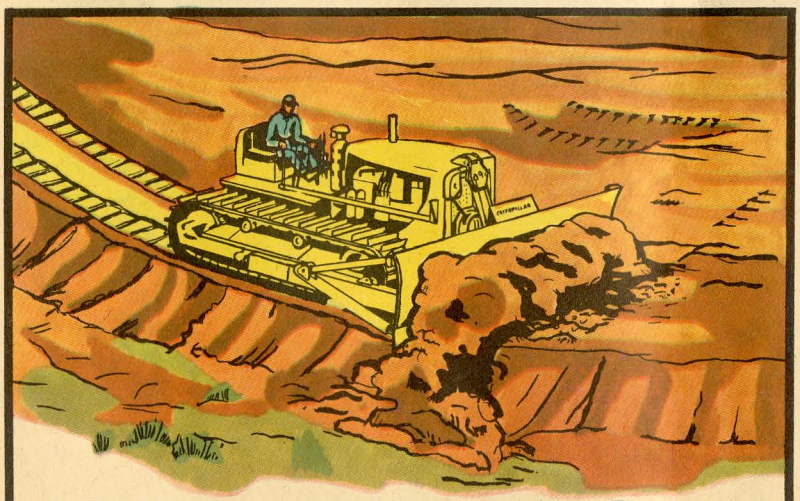
IF YOU DO GET STUCK FOLLOW THESE RULES



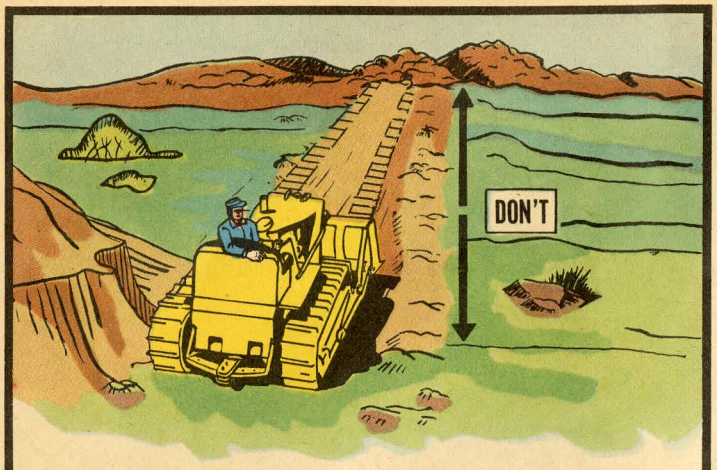
1. Use half throttle only. . .
2. Engage flywheel clutch slowly. . .
3. Keep both steering clutches engaged, don't twist or turn. Good operators seldom get mired down.



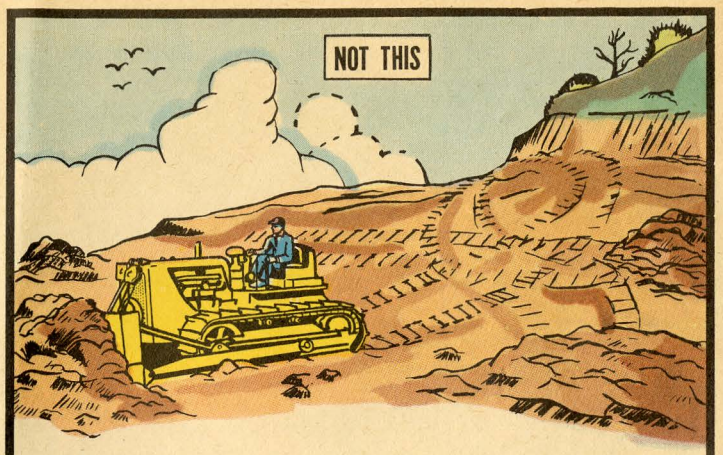
. . .work up and down the road with blade angled to drift material into low spots and to cut off high places. Angled blade also windrows earth to one side for easy disposal. If a straight blade is used, work diagonally across the road.



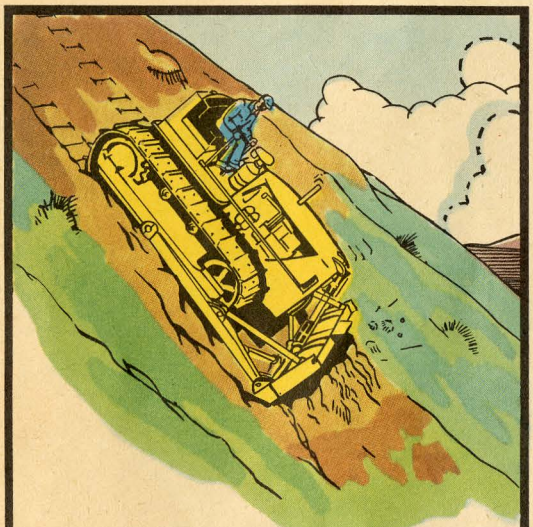
Angling blade dozers are ideal for widening fills. Travel a foot or so from the slope line so that earth rolling off the blade end will fall over the edge.



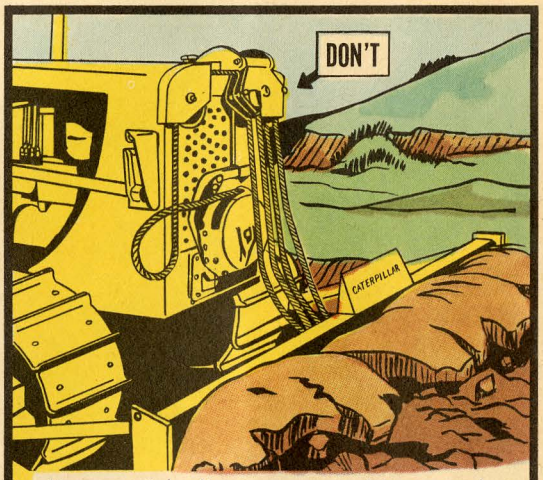
Don't back up further than necessary and don't push earth for greater distances than required. These are common faults of inexperienced operators.



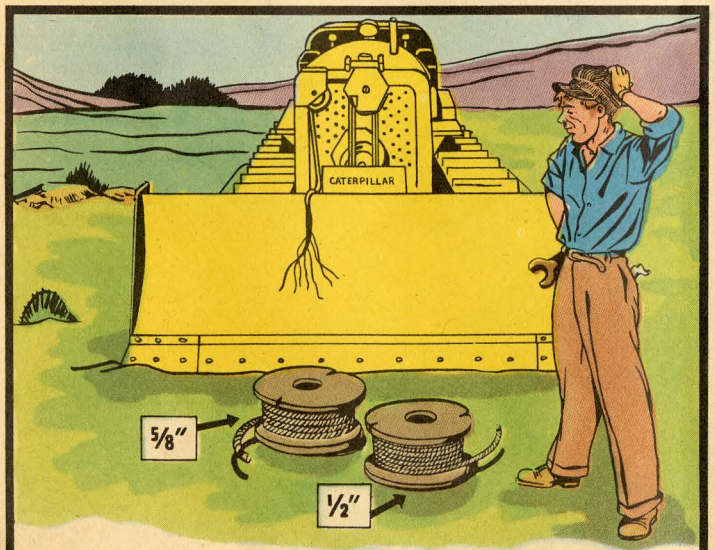
Know where the next pass is going to be made and where material will be placed. Always have a plan of operation.



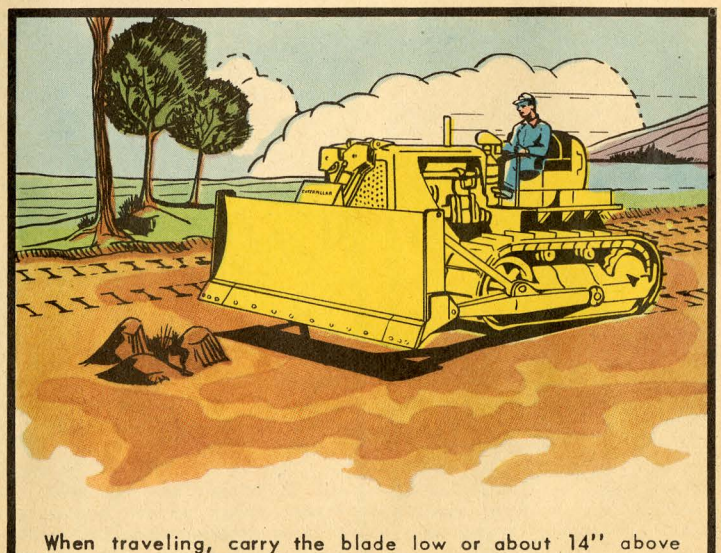
When dropping down a steep hill or over the side of a fill, use blade for a brake.



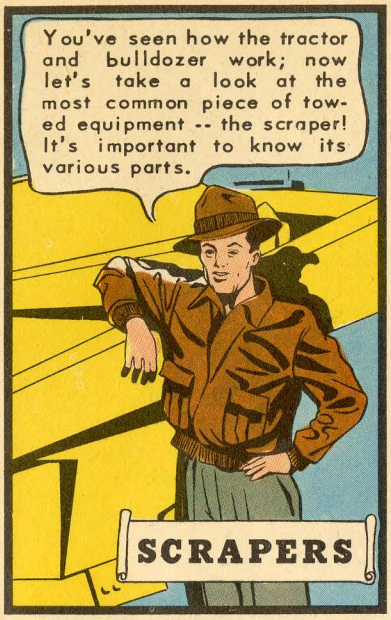
Keep a tight line on your cable control. Excessive slack in line during operation tends to cause kinks and uneven spooling which may result in premature breakage, or flattening of cable on drum.

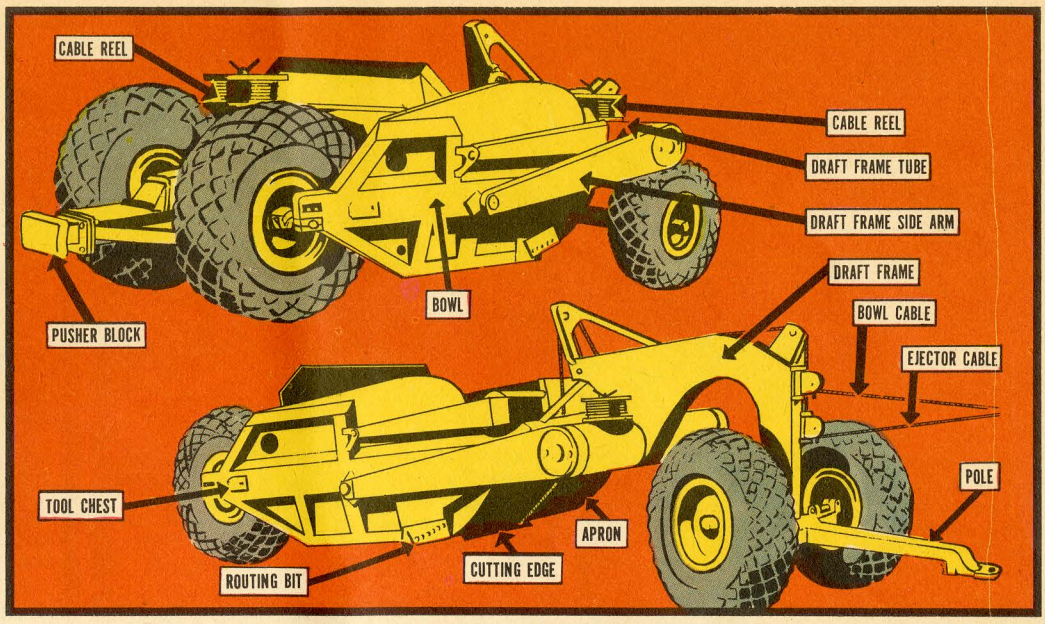


Always use the correct sized cable and type specified by the tractor and bulldozer manufacturer.

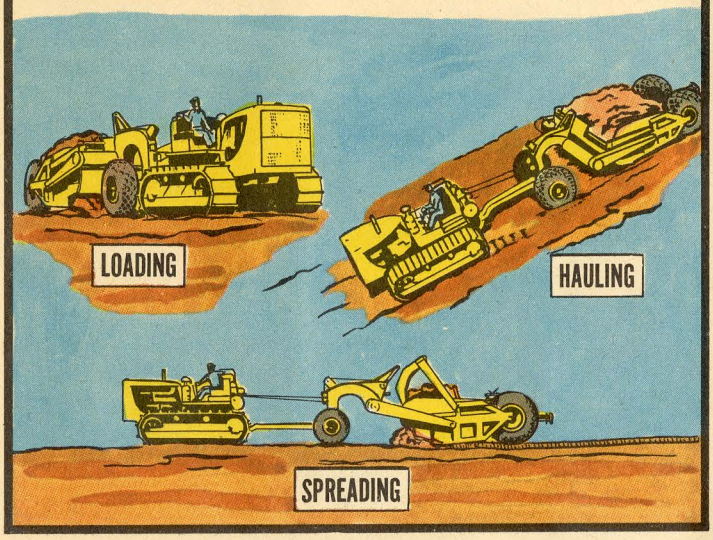


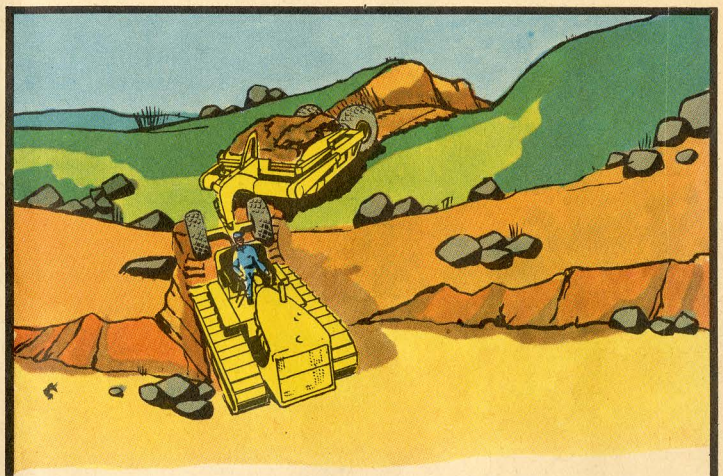
When traveling, carry the blade low or about 14" above the ground. This practice helps protect crankcase and vital parts of the tractor.



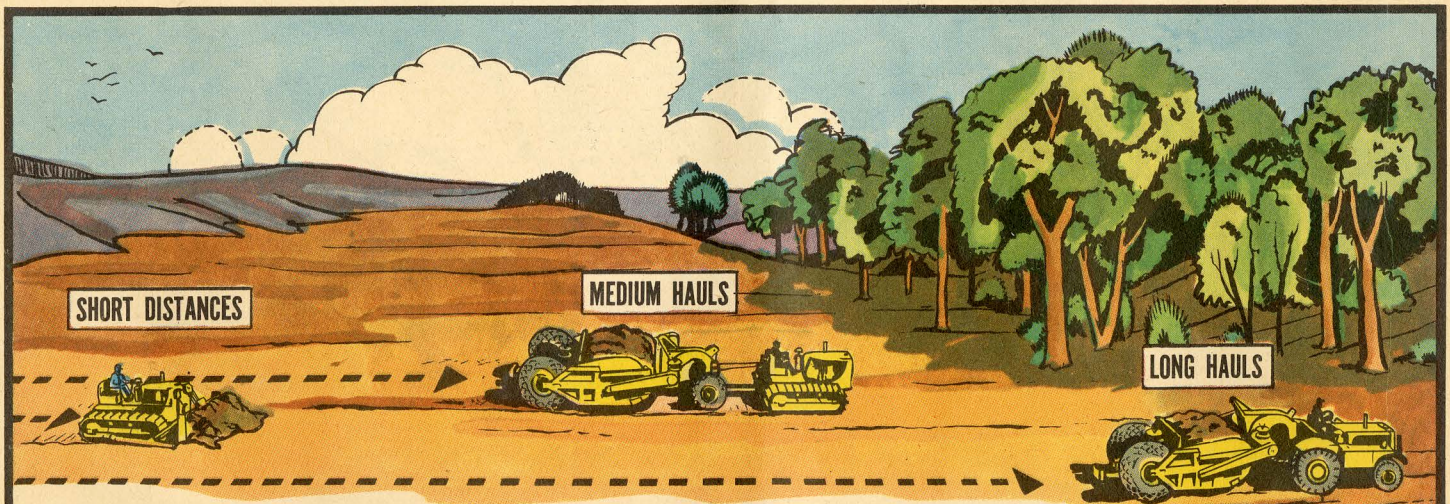


The tractor-drawn scraper is a one-man tool, requiring only the operator to perform the jobs of . . .

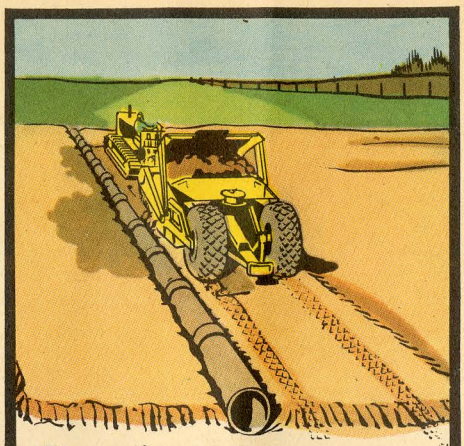




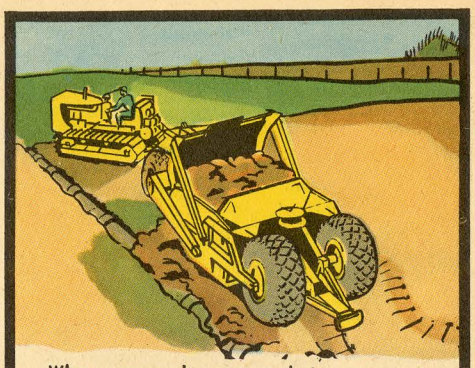
The tractor-drawn scraper is used most efficiently where power, rather than speed, is the essential factor. . . . where large loads must be pulled at lower speeds, due to poor ground conditions, usually on medium length hauls.



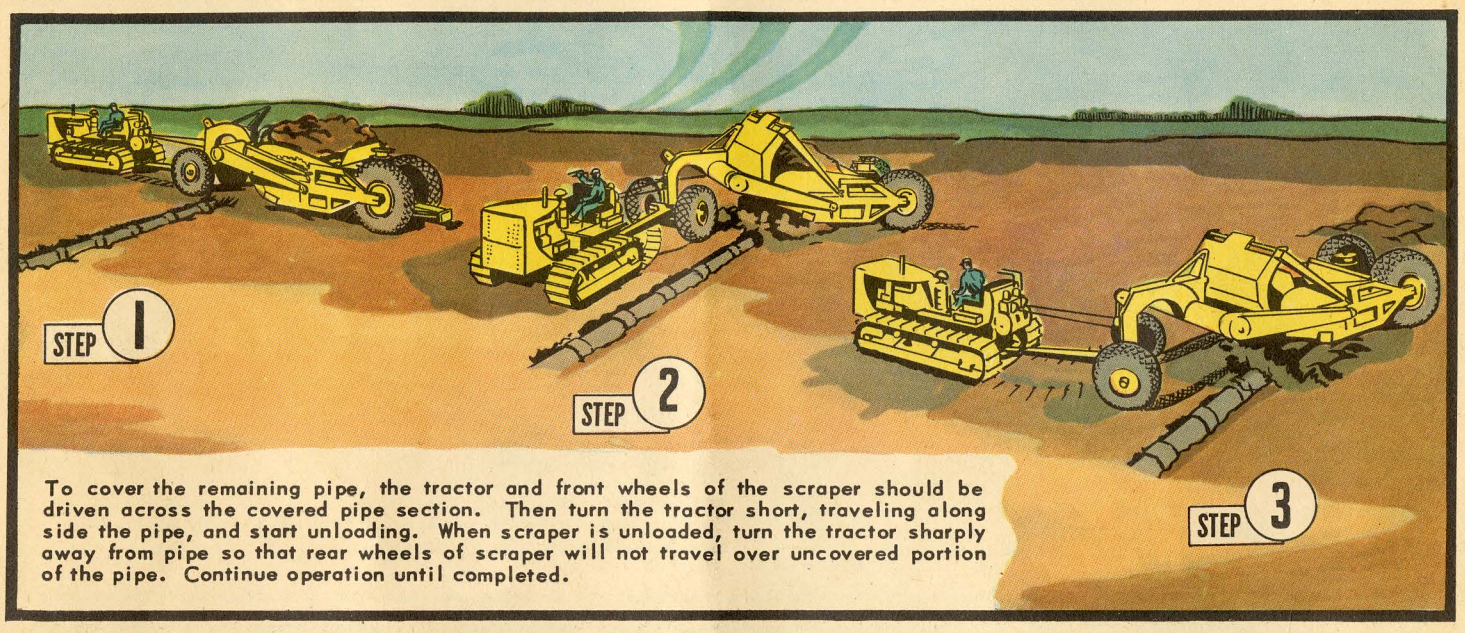
Proper application of equipment-to-job means more efficient operation. Short hauls are usually handled by tractor-'dozer combination, medium hauls by tractor-scraper combination, and long hauls by high-speed, rubber-tired rigs. This is zoning the job, and zoned jobs are profit jobs.



First, the tractor and scraper should spread along each side of the pipe and unload material as close to the pipe as possible. Alternate loads to each side to eliminate moving culvert out of line.

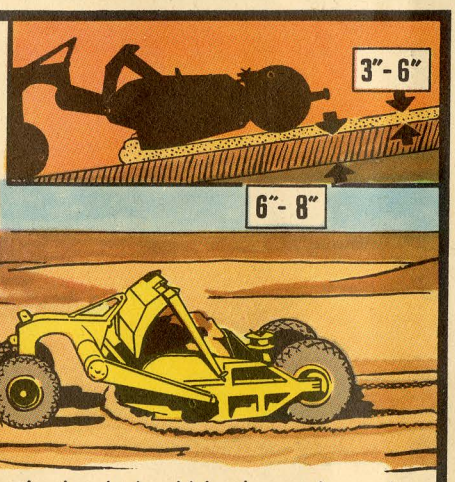


When enough material is present, rack the steering clutches so that the tractor swings and twists as it travels parallel to the pipe, thus pushing material against the pipe and compacting it. Repeat this procedure until about 20 feet of pipe is covered with 12 inches of fill. The tractor can now pass over the pipe without danger of damage.

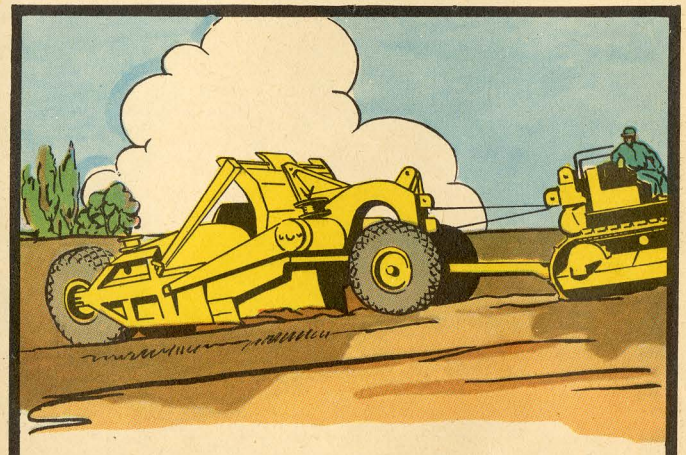


To cover the remaining pipe, the tractor and front wheels of the scraper should be driven across the covered pipe section. Then turn the tractor short, traveling along side the pipe, and start unloading. When scraper is unloaded, turn the tractor sharply away from pipe so that rear wheels of scraper will not travel over uncovered portion of the pipe. Continue operation until completed.

If possible, unload or spread down hill at highest possible speed. Spread in thin layers for better compaction -- about 6 to 8 inch layers for earth, 3 to 6 inches for sand. Generally, depth of spread is set up in job specifications.

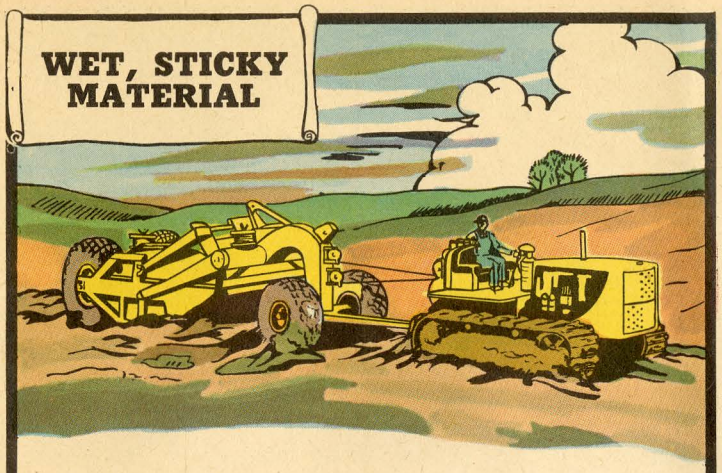


For controlled spreading, the bowl should be lowered to the desired depth of spread. Raise the apron as the tractor moves forward so that the material falls out and uniformly rolls under the cutting edge. Move ejector plate forward steadily for uniform flow.

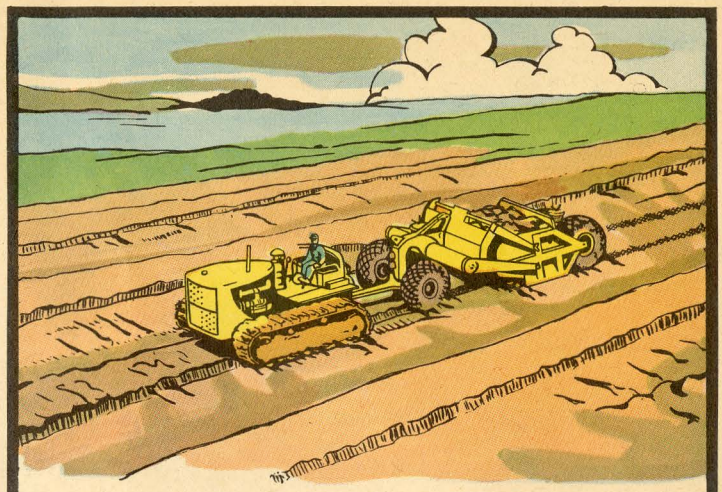


Smooth the fill and haul road when returning to the cut by allowing the ejector to return about 8 inches while the apron is still in the raised position. Lower bowl until it touches the ground. Then raise the bowl slightly so that it will cut off the high spots.

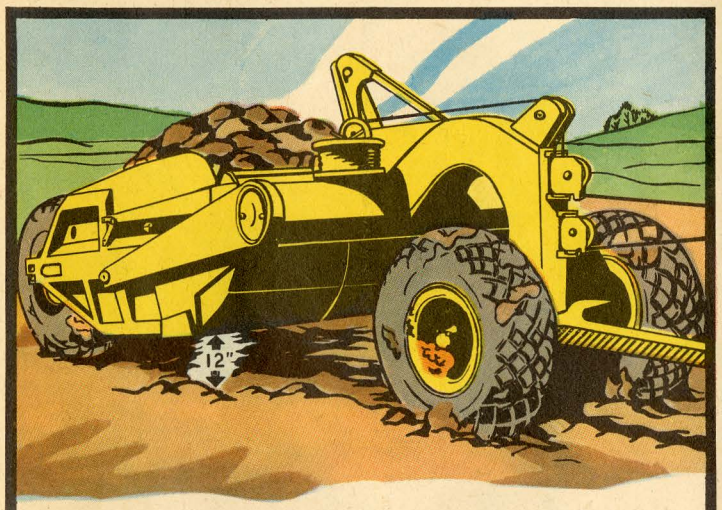
WET, STICKY MATERIAL



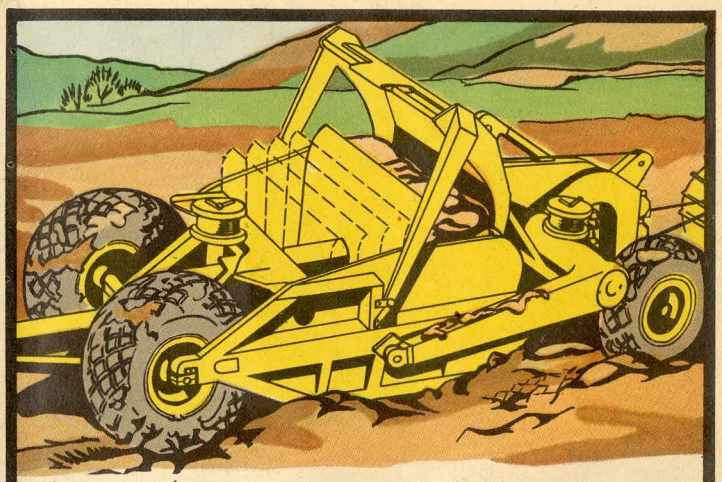
When loading wet, sticky material, where traction is bad, best results will be obtained by taking a thin cut. Keep apron as low as possible to prevent material from banking up in front.



Straddle loading may be used in wet, sticky material to improve performance.

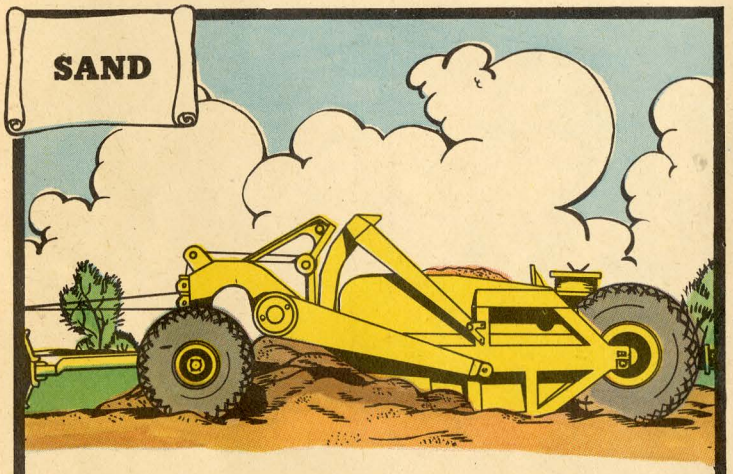


When unloading, raise bowl a foot or more before spread is started. This gives needed clearance for material to pass under the bowl.

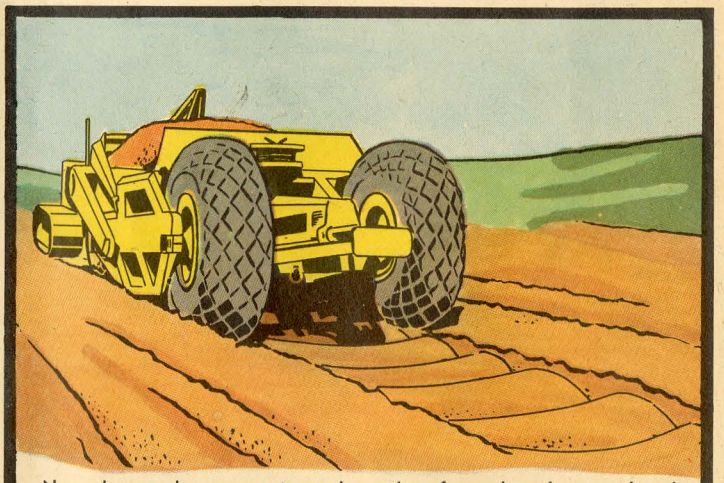


Now raise the apron to its maximum height and bring the ejector plate forward slowly --- about 12 inches at a time. After each movement forward, permit the ejector plate to return about 6 inches. This allows material to fall back and loosen itself.

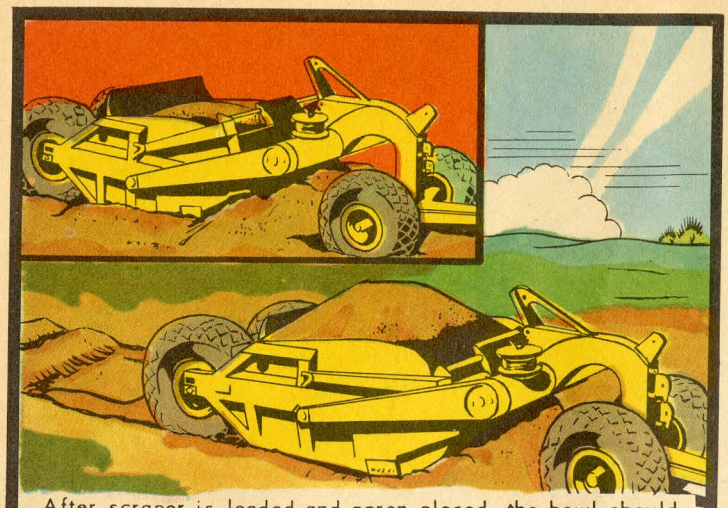
SAND



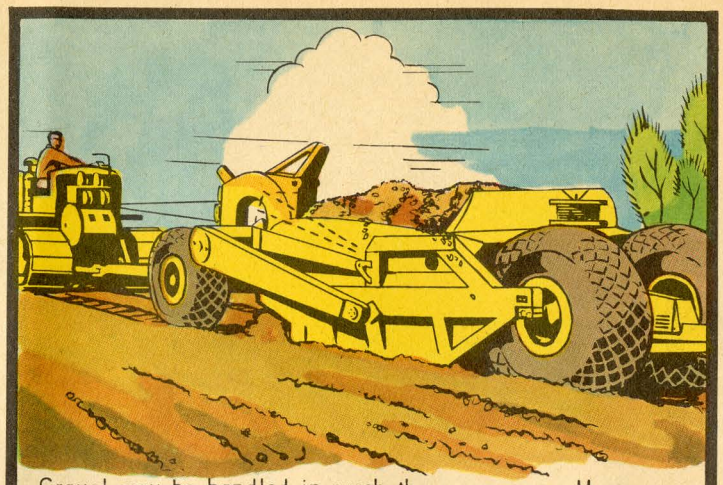
When loading sand, raise the apron at least three feet, and drop the bowl while traveling in second or third gear to take advantage of momentum. Load until engine lugs down. At this point sand will be pushed up in a pile a-head of the blade.



Now lower the apron into the pile of sand and raise bowl at same time. When engine RPM's have picked up, lower the bowl and repeat the operation. Do this until scraper is loaded. This operation is known as "pumping"

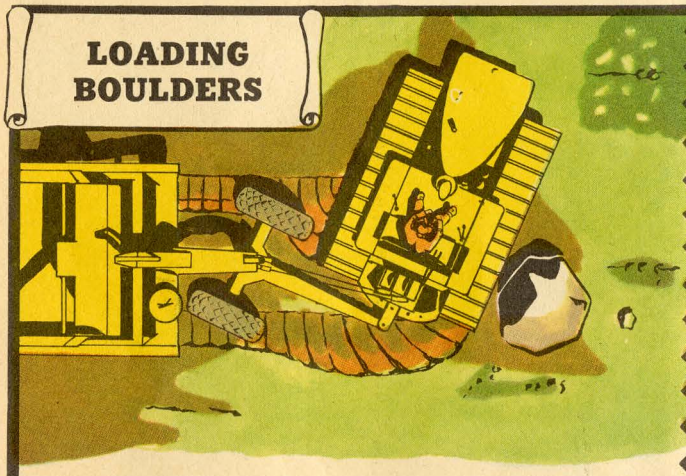


After scraper is loaded and apron closed, the bowl should be raised one to two inches above the ground and held in this position while traveling forward several feet. This will level off the pile of loose material in front of the apron.

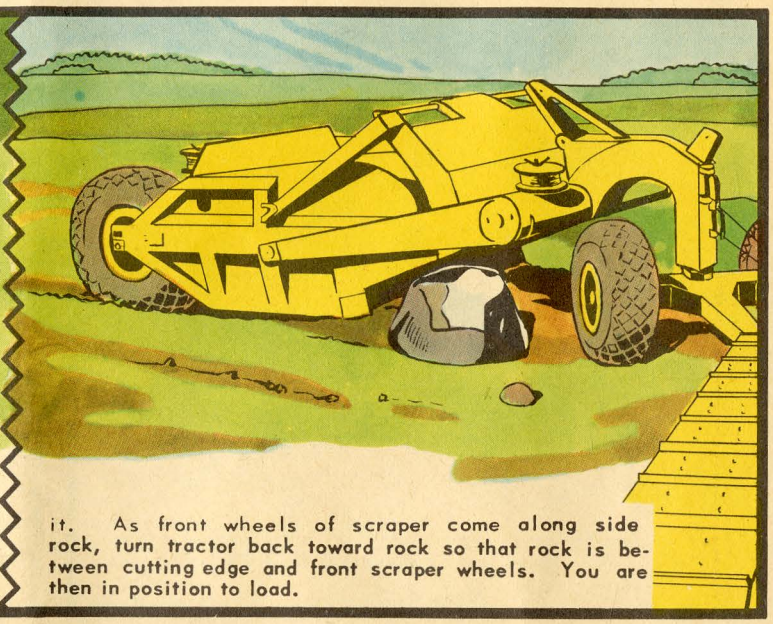


Gravel may be handled in much the same way. However, at times it may be difficult to close the apron when pumping in gravel. If this should happen, back up the scraper a few inches with cutting edge still in the ground and at same time lower the apron while raising the bowl.

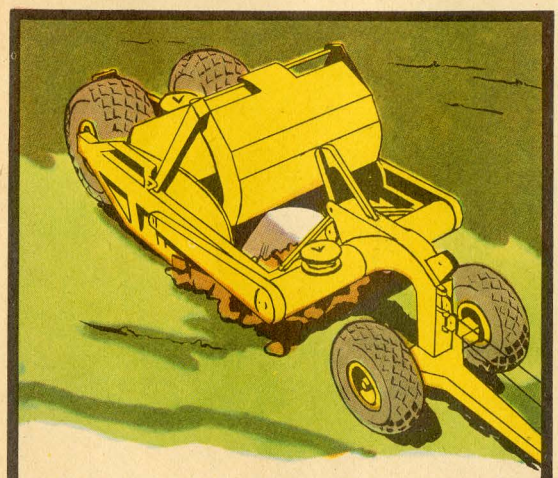
LOADING BOULDERS



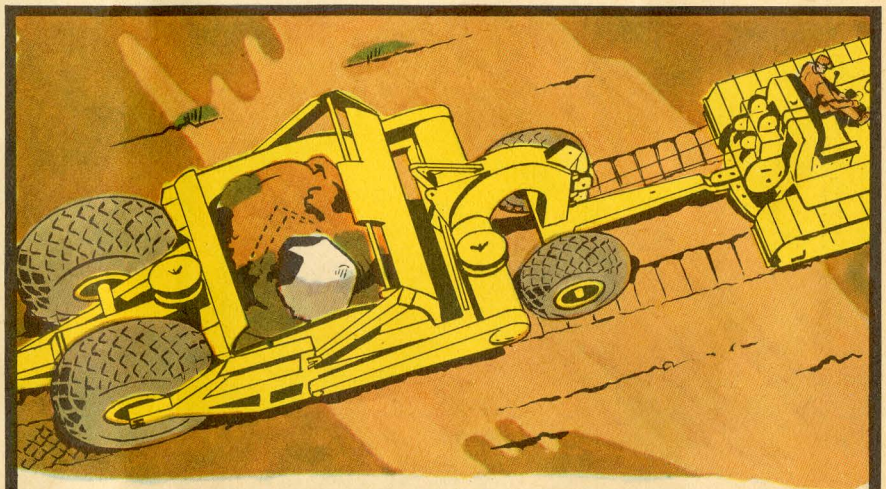
When rock is positioned so that tractor and front scraper wheels cannot be driven over it, head tractor straight for rock and turn sharply just before reaching it.



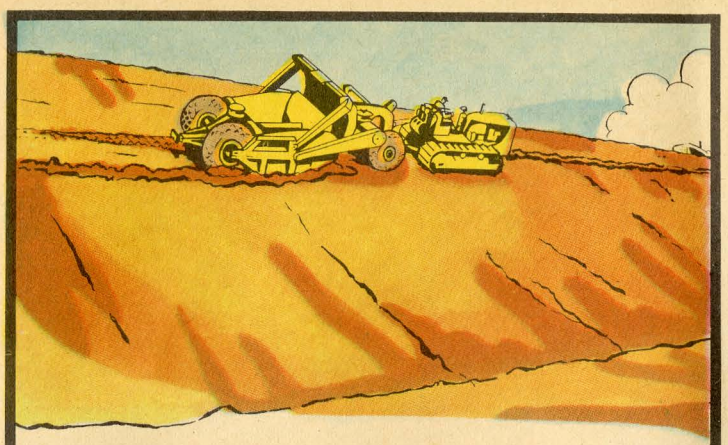
As front wheels of scraper come along side rock, turn tractor back toward rock so that rock is between cutting edge and front scraper wheels. You are then in position to load.



When the rock has been lifted sufficiently and starts to slide back into the bowl, pull ahead several feet so that earth will push the rock back far enough to permit closing the apron.

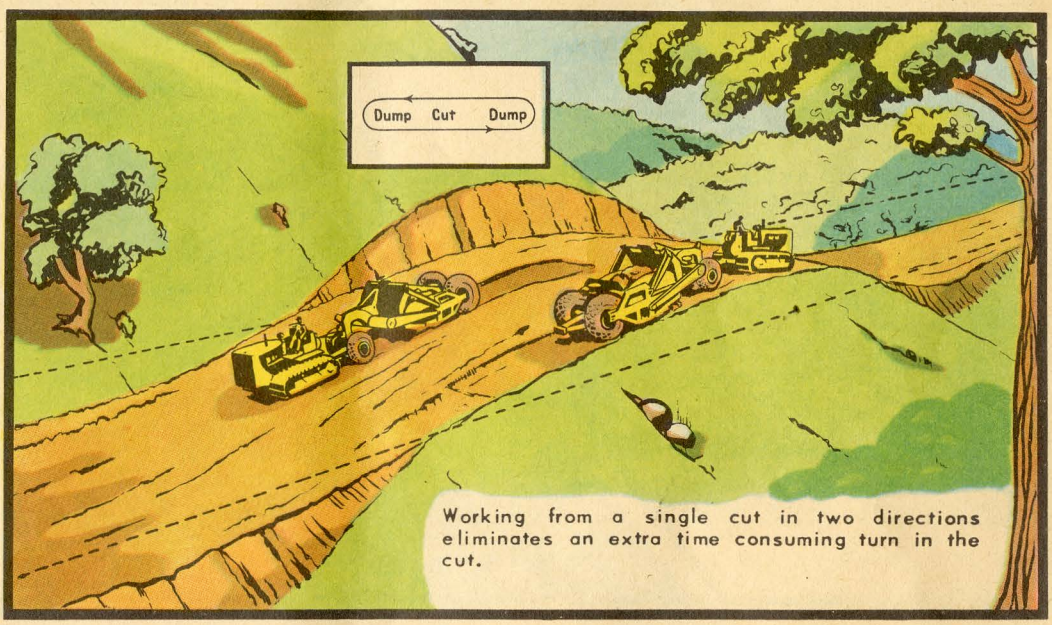


If rock becomes stuck while unloading, force material into bowl to change its position. Then eject. After rock is unloaded, swerve sharply to clear the rock.

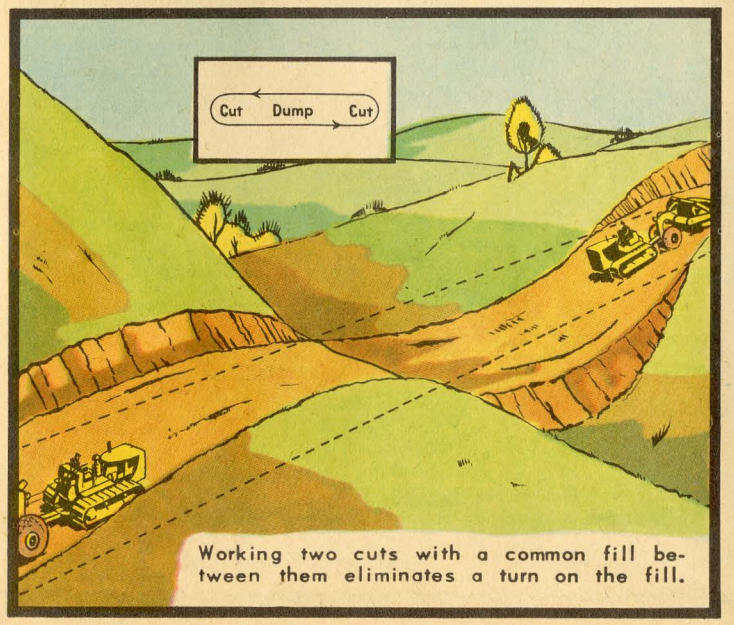


The scraper can be used to finish side slopes in this manner: Raise apron and bring ejector forward to within six inches of front position. Then drive onto slope, parallel to road, and lower cutting edge so that it is just dragging and smoothing slope.

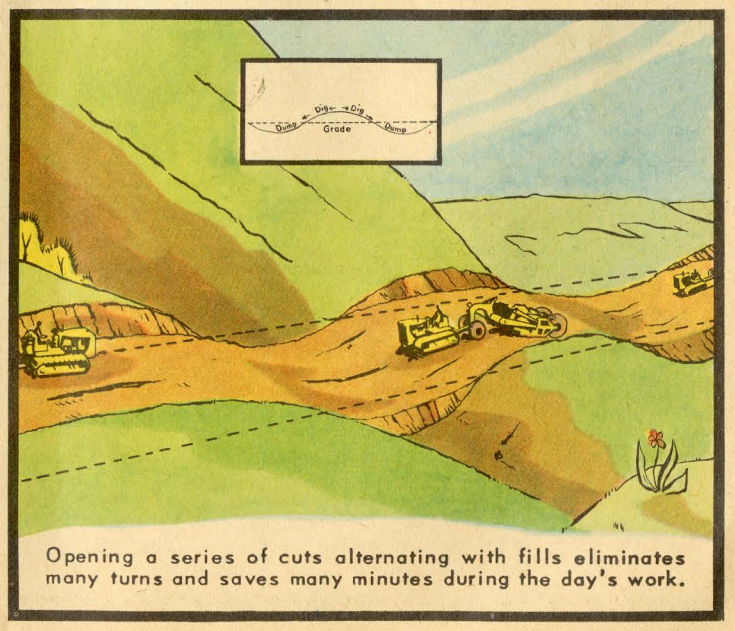
Start finishing at top of slope so that material will roll to the lower side in a windrow. The windrowed material will be worked down to the bottom as successive passes are made.



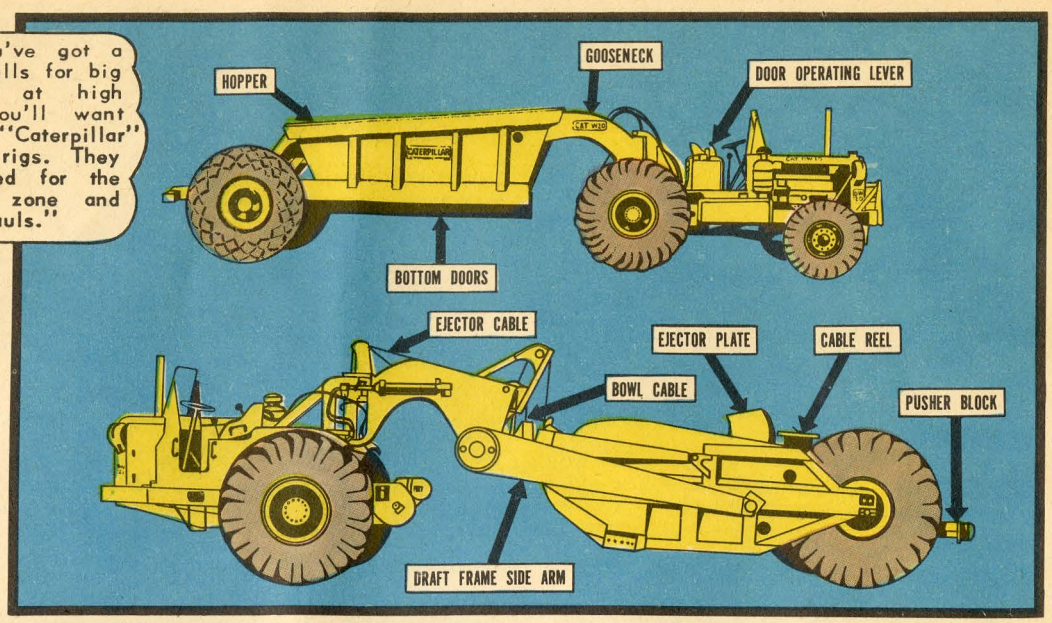
Working from a single cut in two directions eliminates an extra time consuming turn in the cut.

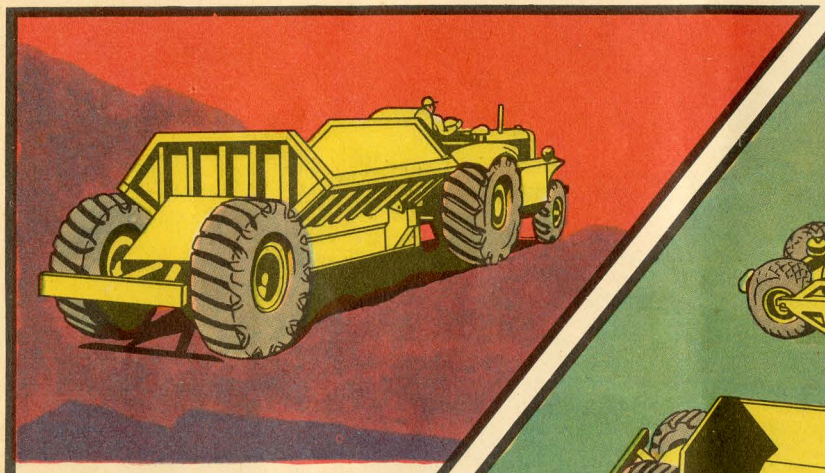


Working two cuts with a common fill between them eliminates a turn on the fill.

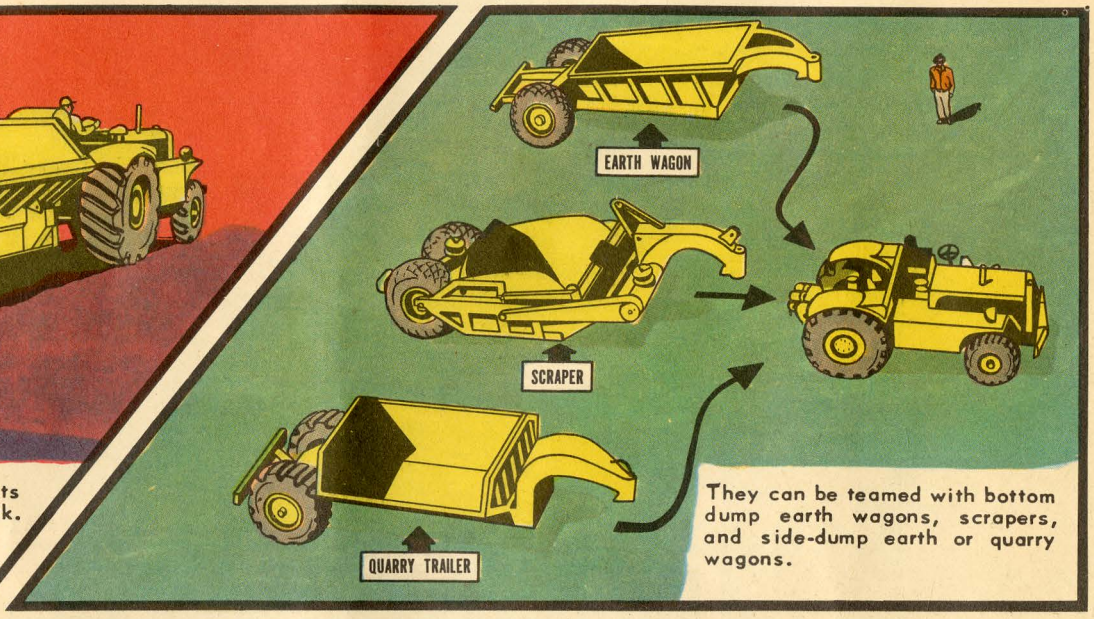


Opening a series of cuts alternating with fills eliminates many turns and saves many minutes during the day's work.

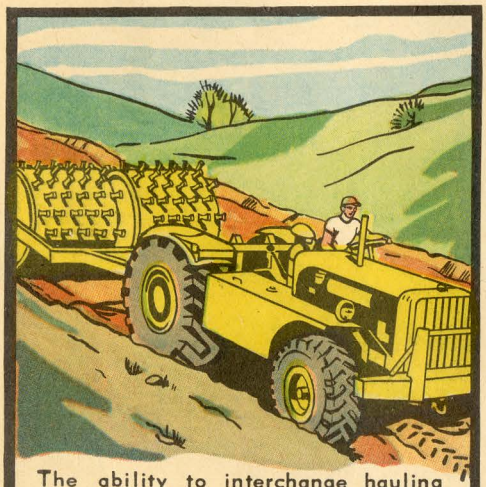




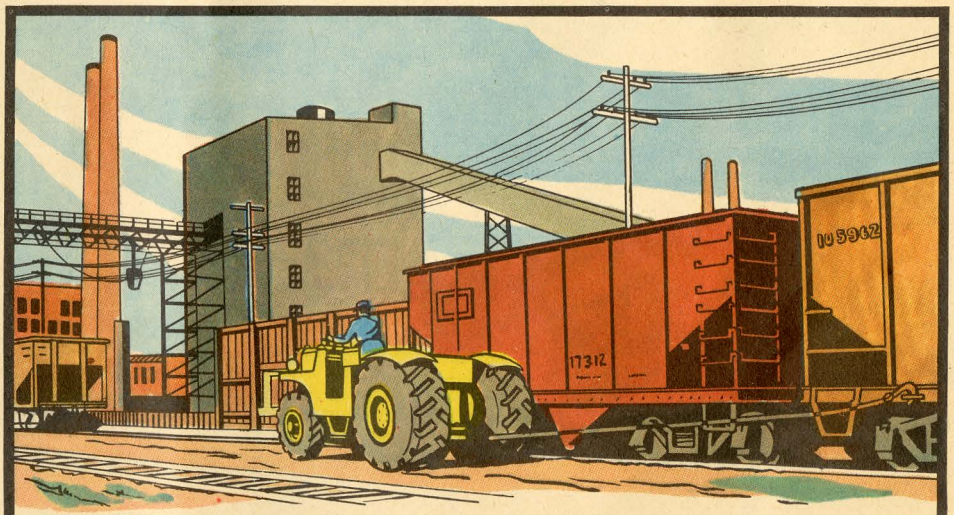
The four-wheel tractor units operate much like a truck.



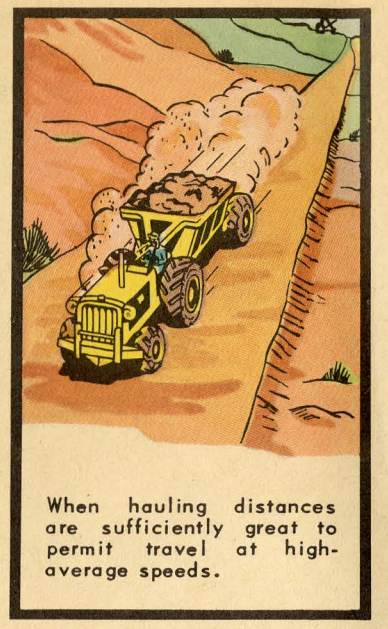
They can be teamed with bottom dump earth wagons, scrapers, and side-dump earth or quarry wagons.



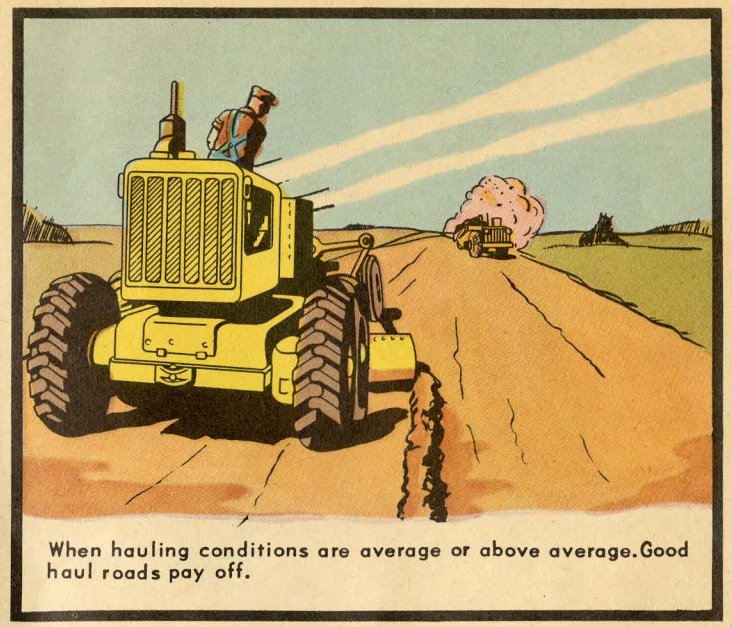
The ability to interchange hauling units is an important feature together with the fact that the unit can be used for drawbar work, independent of towed units. On . . . . . .



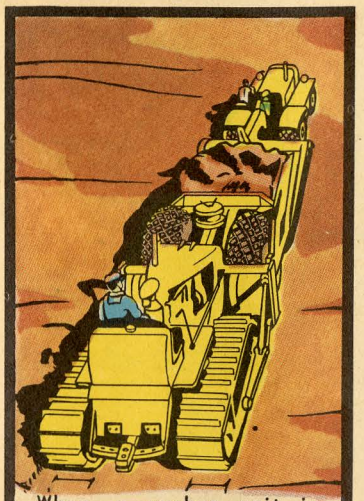
CONSTRUCTION JOBS, BULLDOZING WORK, INDUSTRIAL PLANTS, AND WATER WAGONS.



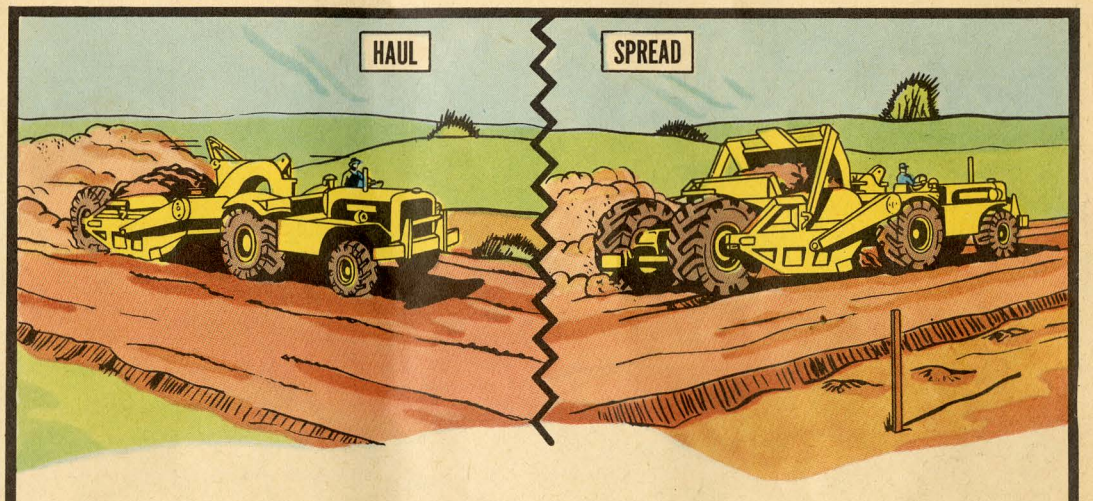
When hauling distances are sufficiently great to permit travel at high-average speeds.



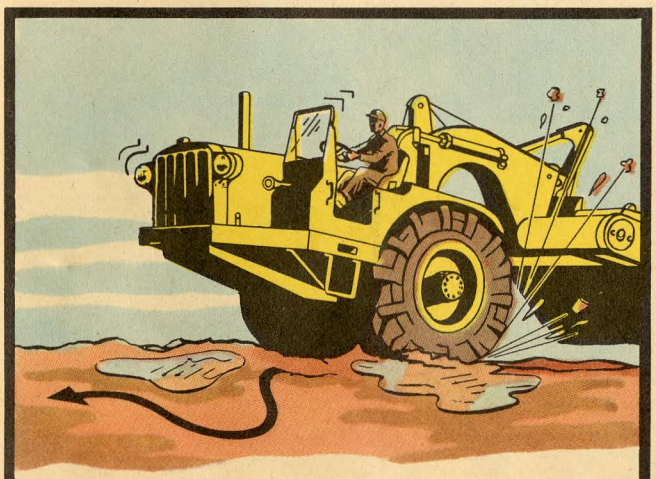
When hauling conditions are average or above average. Good haul roads pay off.



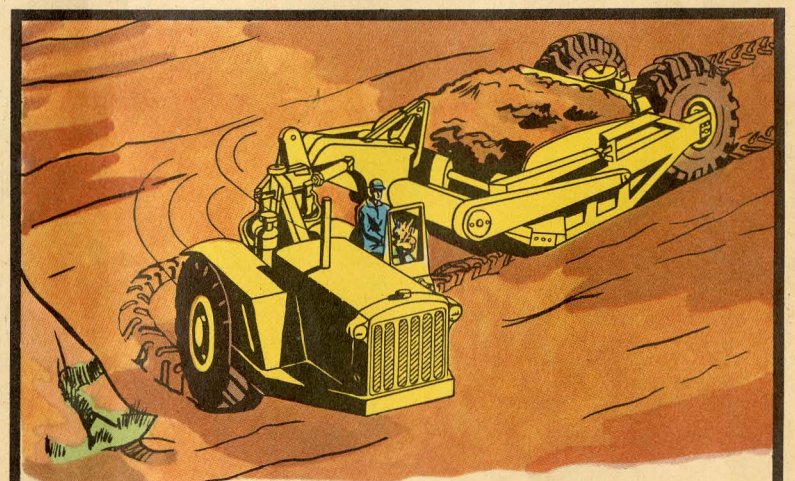
When a pusher unit is available to help in loading. (Self-loading with rubber-tired rigs is not efficient in most cases.)



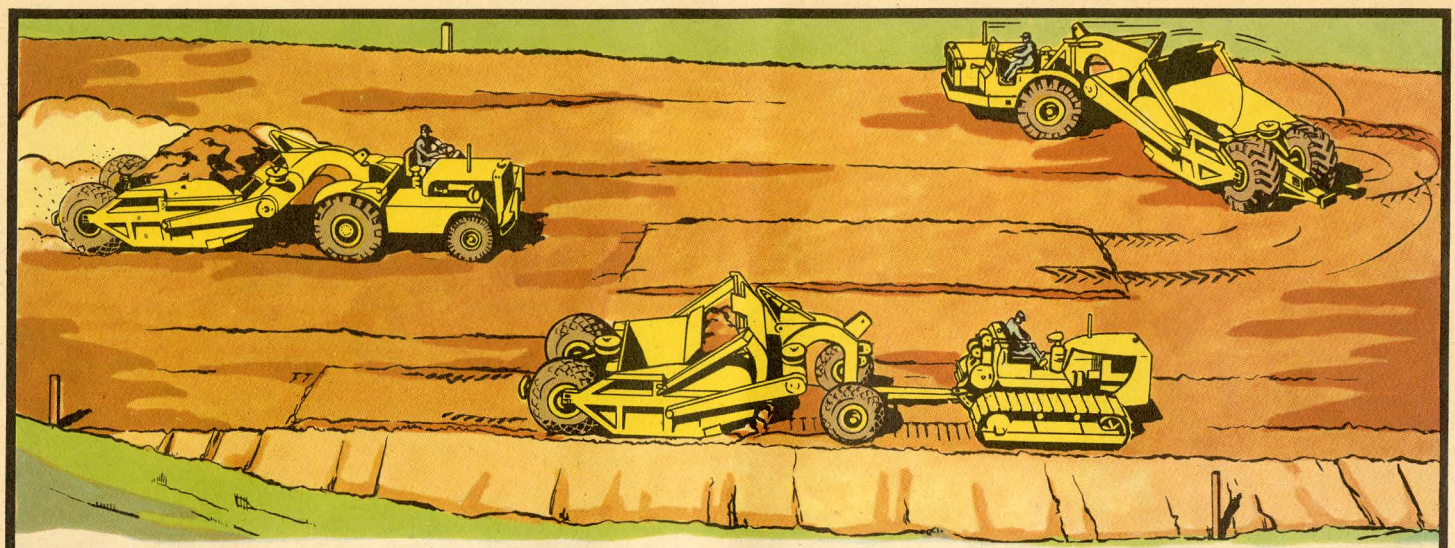
After loading, the wheel-type unit is capable of hauling, spreading, or windrowing and returning to the cut using it's own power and traction.



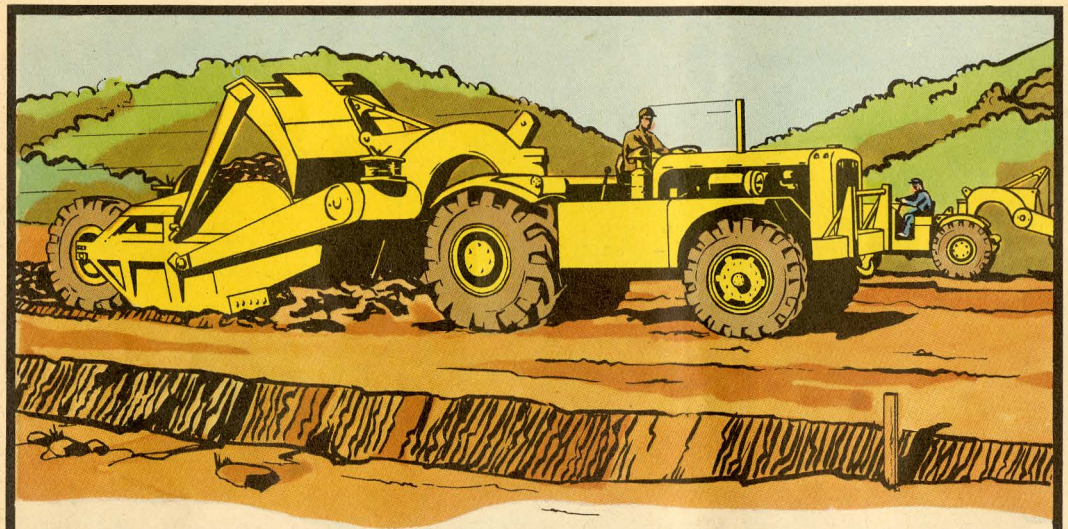
When traveling in poor footing, brakes may be used to maneuver out of soft spots. This is accomplished by applying the brake to the wheel that is slipping, thus throwing full power to the drive wheel with the best footing.



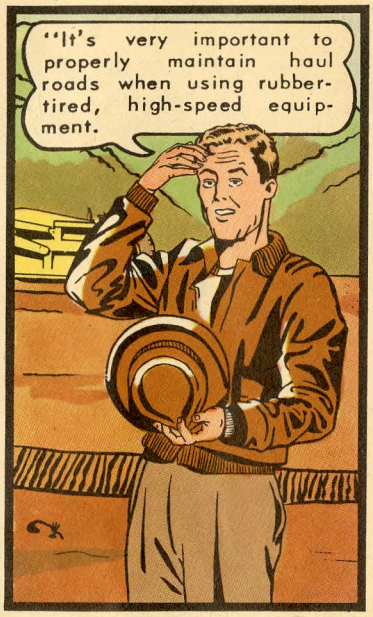
Brakes may also be used to aid in making sharp turns. Apply brake on the side of direction-of-turn and unit will swing sharply without moving forward. Brakes should be used in making turns only at slow speeds.

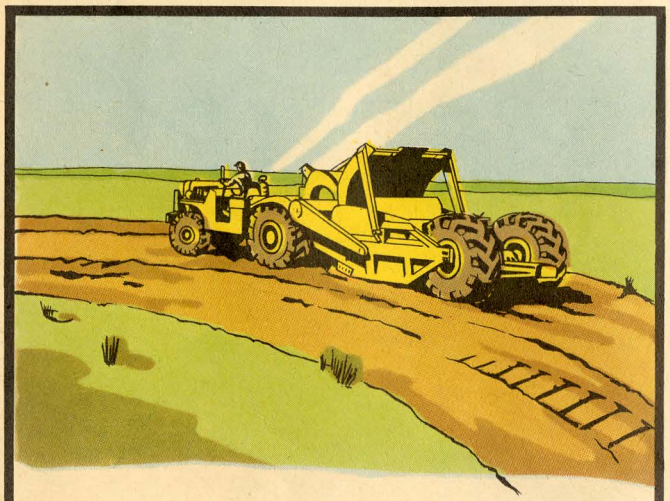


Because of speed, wheel units should be given preference over other equipment at the fill. Let the wheel-type equipment spread in the middle or over areas where they can turn fast and get back to the cut.

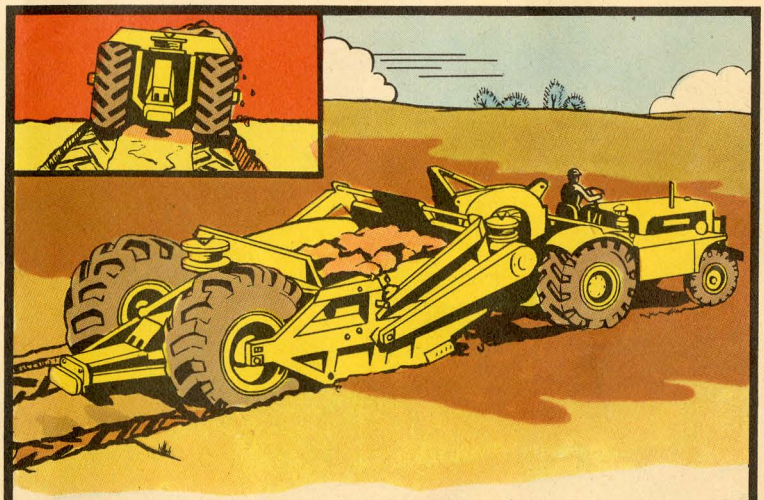


Enter fill at highest, safe speed and begin spreading without slackening speed. Proper lift can be maintained by controlling blade height.

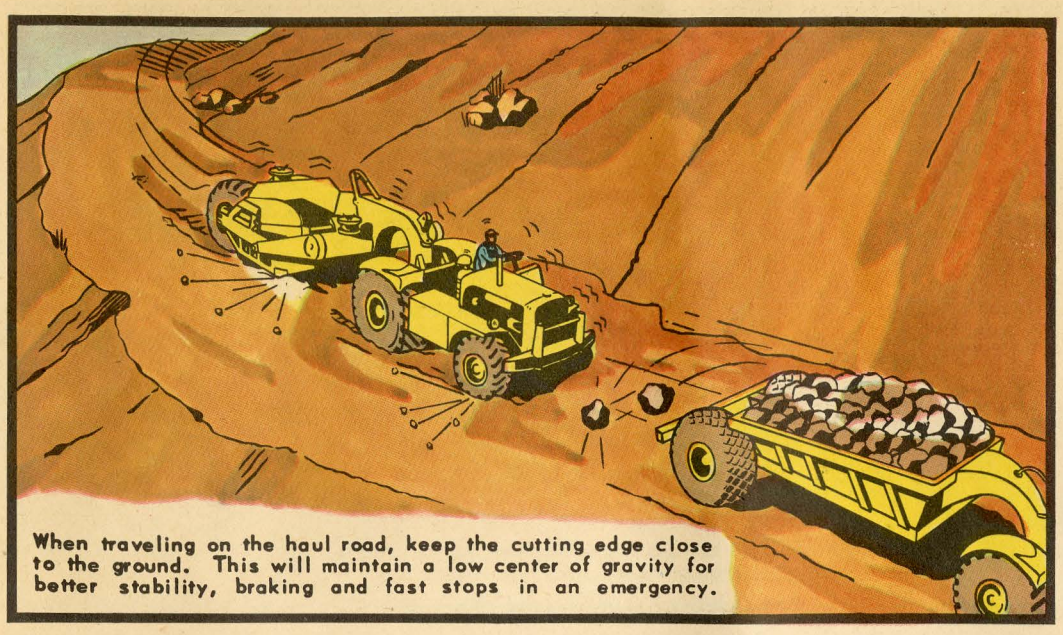




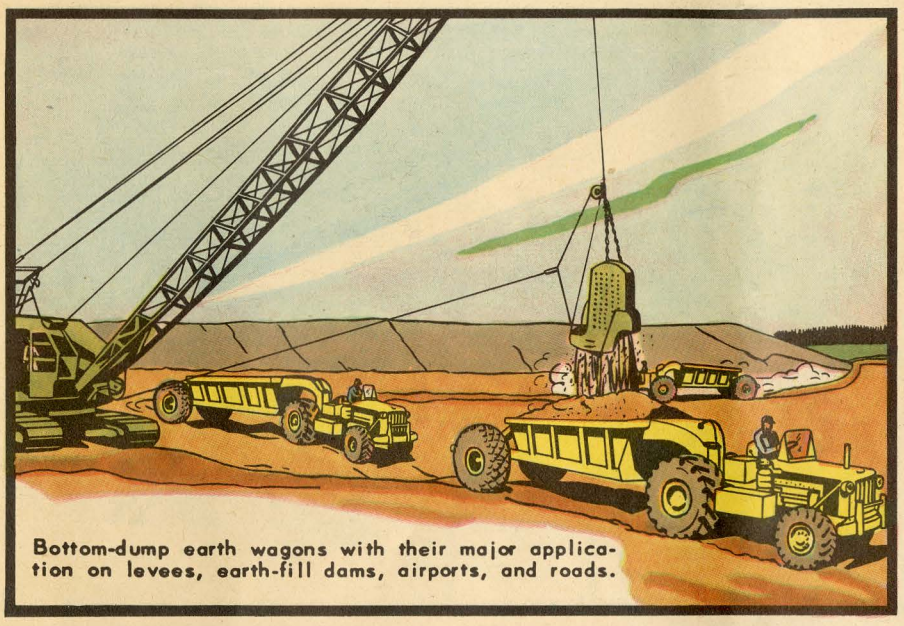
If no motor grader or bulldozer is available, maintain haul road by the same method as used in smoothing a fill --- by occasionally dragging the cutting edge.



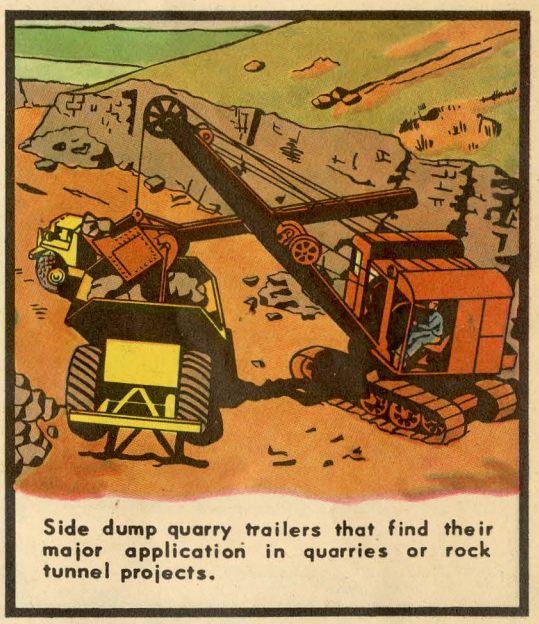
If material begins loading faster in one side of scraper than the other, check air pressure in the scraper tires.



When traveling on the haul road, keep the cutting edge close to the ground. This will maintain a low center of gravity for better stability, braking and fast stops in an emergency.

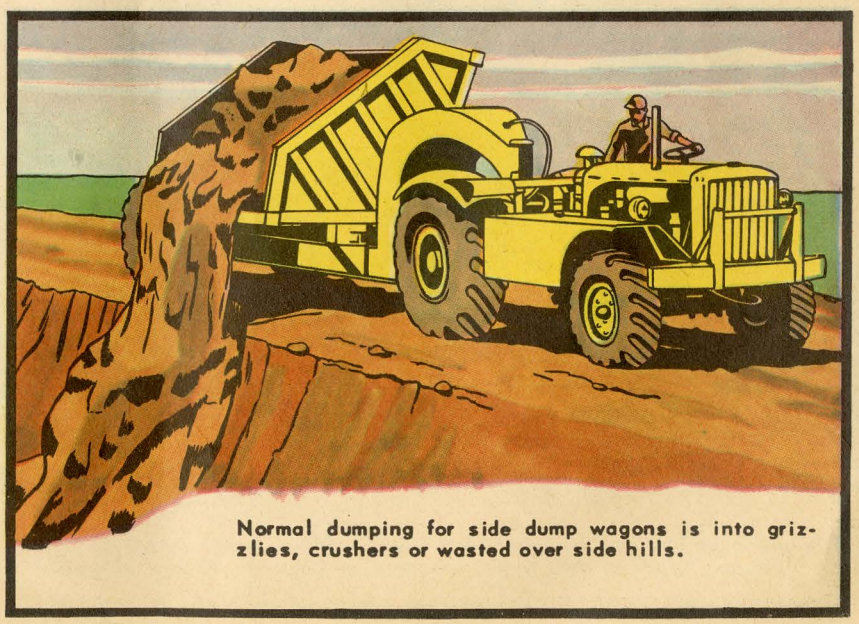


Bottom-dump earth wagons with their major application on levees, earth-fill dams, airports, and roads.

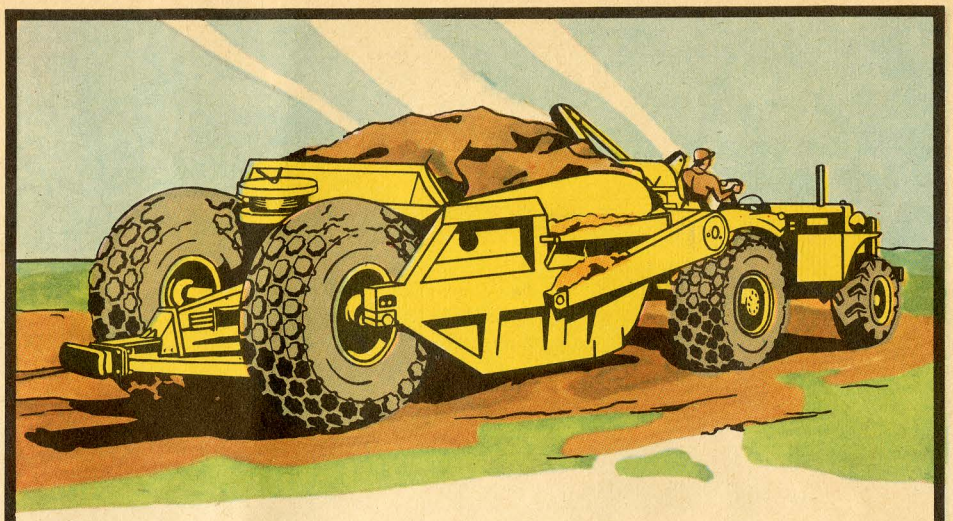


Side dump quarry trailers that find their major application in quarries or rock tunnel projects.

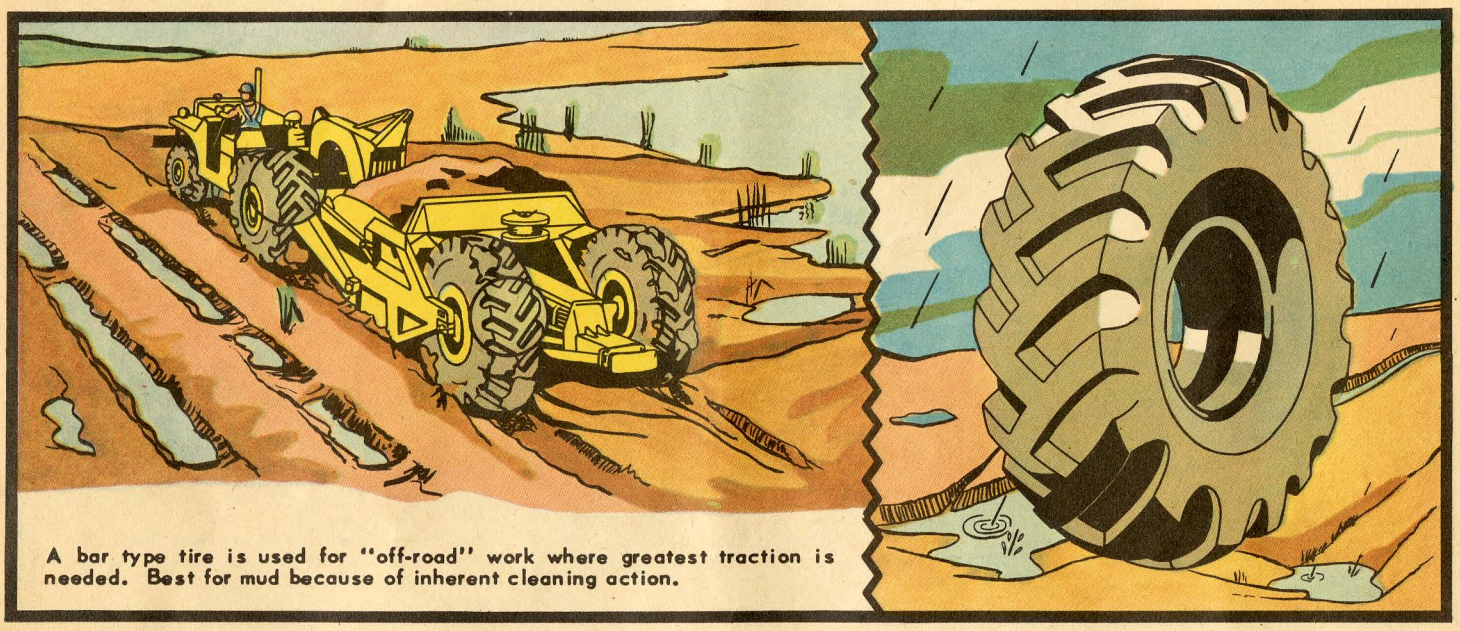
Dumping with bottom-dump wagons is done in controlled windrows The size of windrow can be controlled by width of door opening.



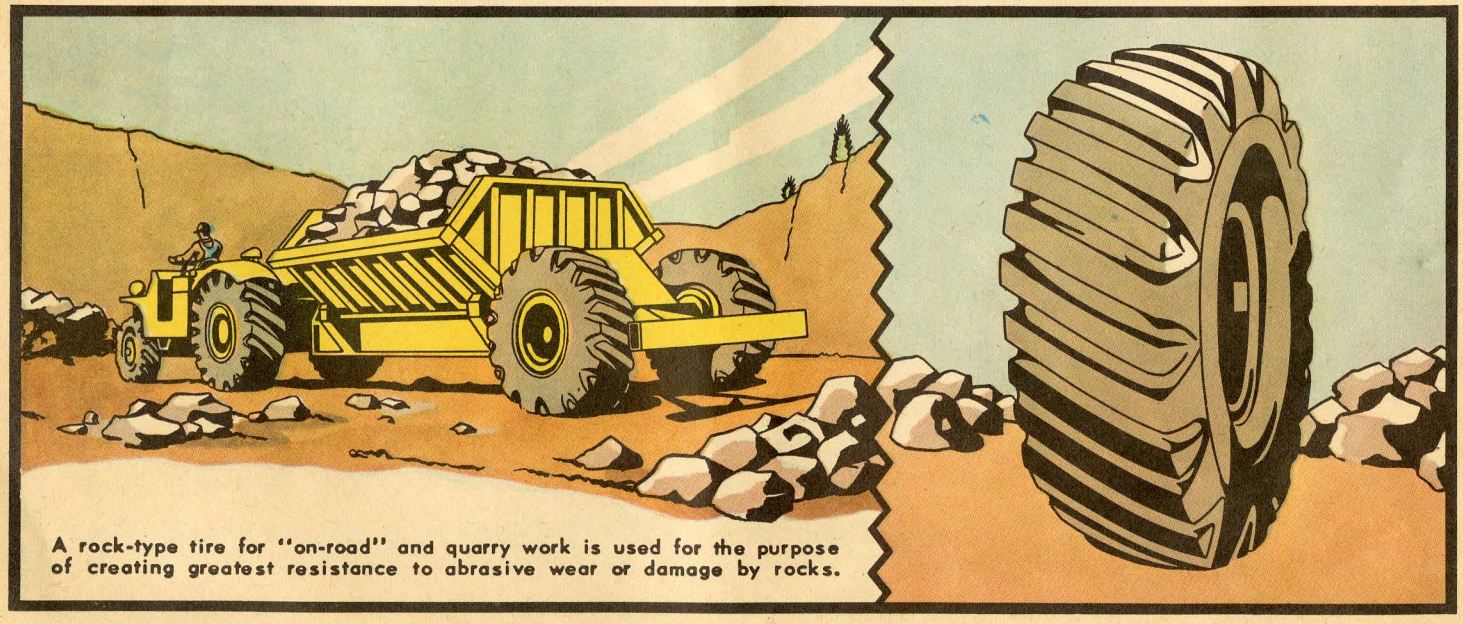
Normal dumping for side dump wagons is into grizzlies, crushers or wasted over side hills.



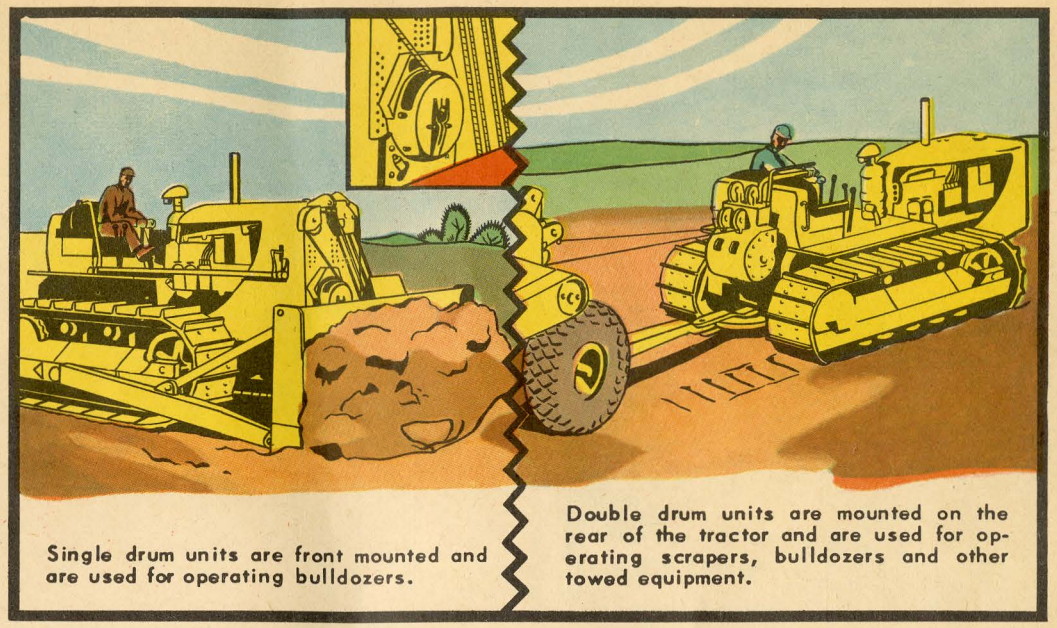
A button-type tire for greatest flotation. This type of tire finds general use on operations other than in mud.



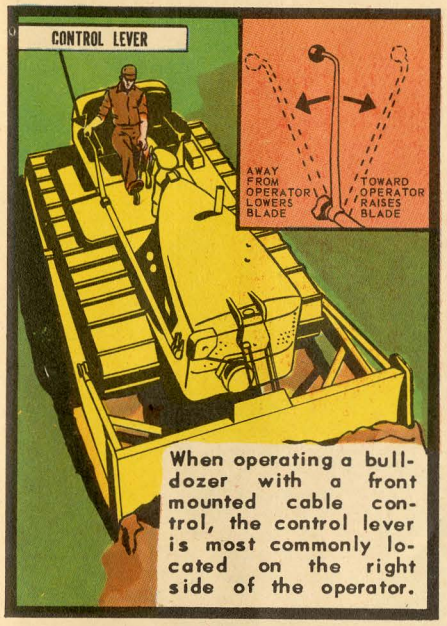
A bar type tire is used for "off-road" work where greatest traction is needed. Best for mud because of inherent cleaning action.



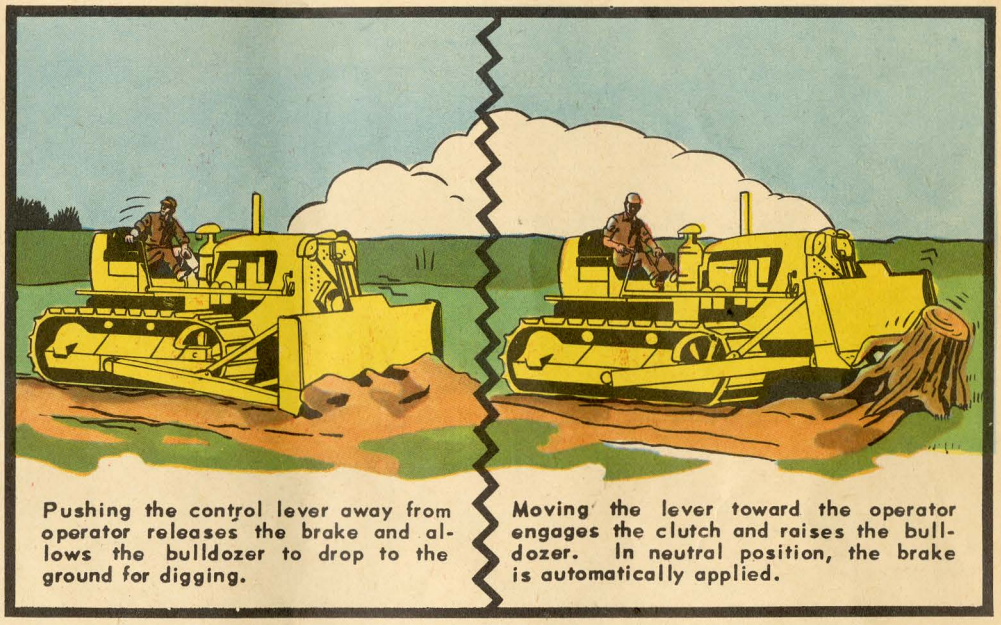
A rock-type tire for "on-road" and quarry work is used for the purpose of creating greatest resistance to abrasive wear or damage by rocks.


Single drum units are front mounted and are used for operating bulldozers.

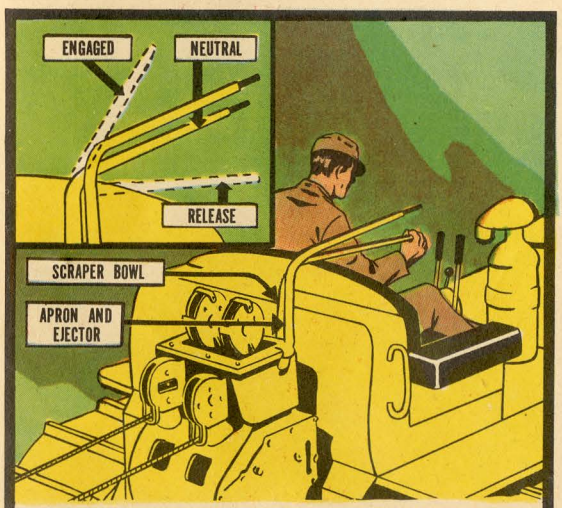
Double drum units are mounted on the rear of the tractor and are used for operating scrapers, bulldozers and other towed equipment.



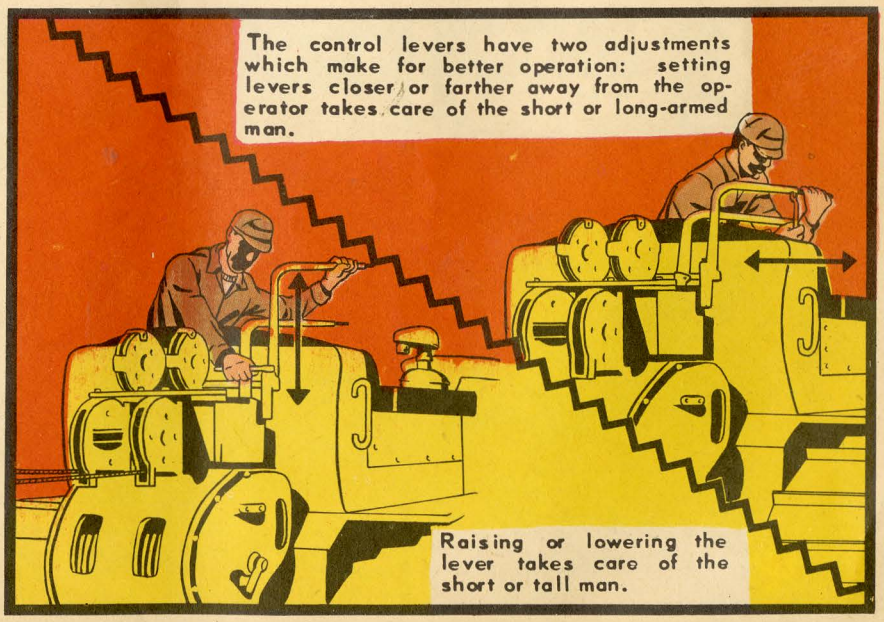
When operating a bulldozer with a front mounted cable control, the control lever is most commonly located on the right side of the operator.


Pushing the control lever away from operator releases the brake and allows the bulldozer to drop to the ground for digging.

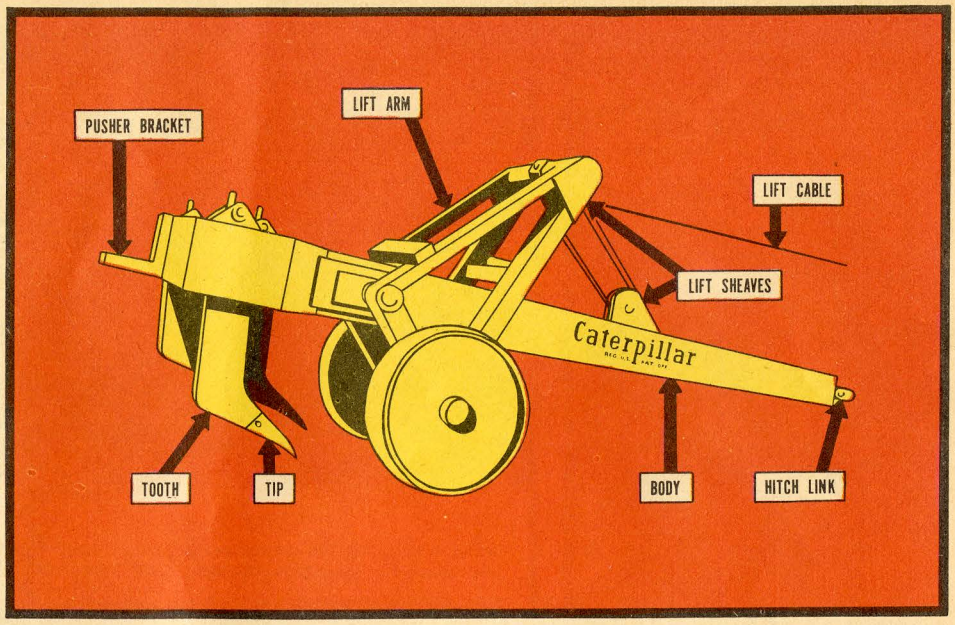
Moving the lever toward the operator engages the clutch and raises the bulldozer. In neutral position, the brake is automatically applied.

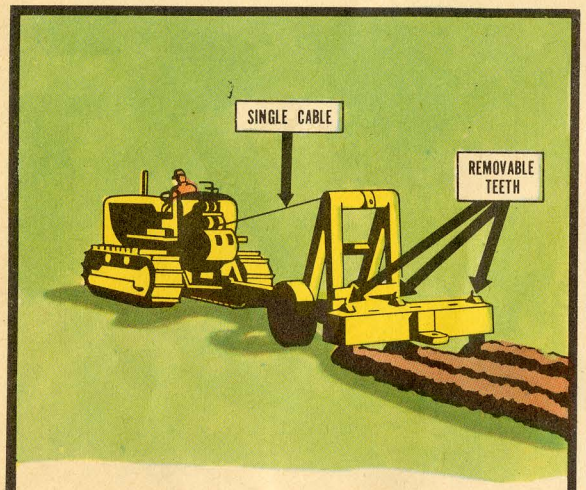


The operator engages either the right or left drum clutch by pulling the proper lever toward himself. Pushing the levers away releases the cable drum brakes.

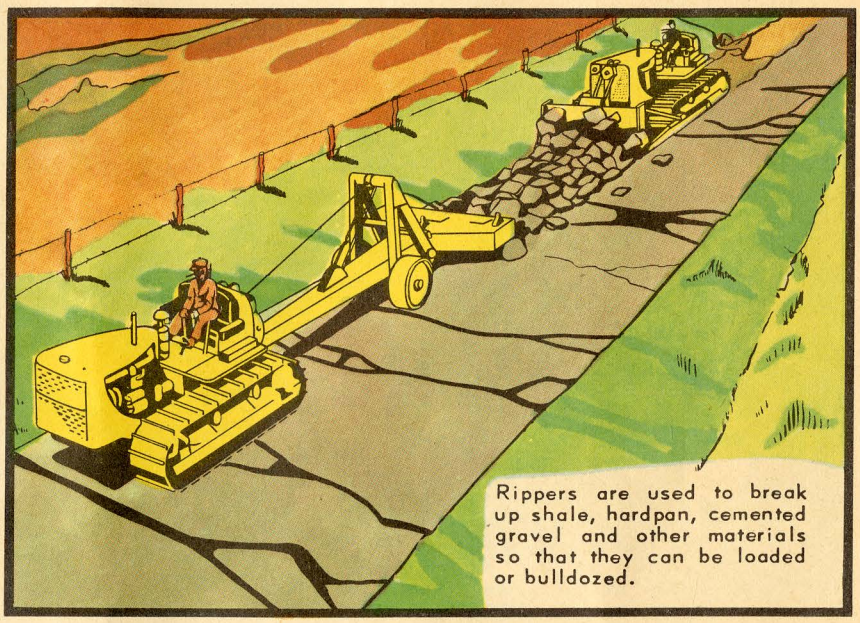

The control levers have two adjustments which make for better operation: setting levers closer or farther away from the operator takes care of the short or long-armed man.

Raising or lowering the lever takes care of the short or tall man.

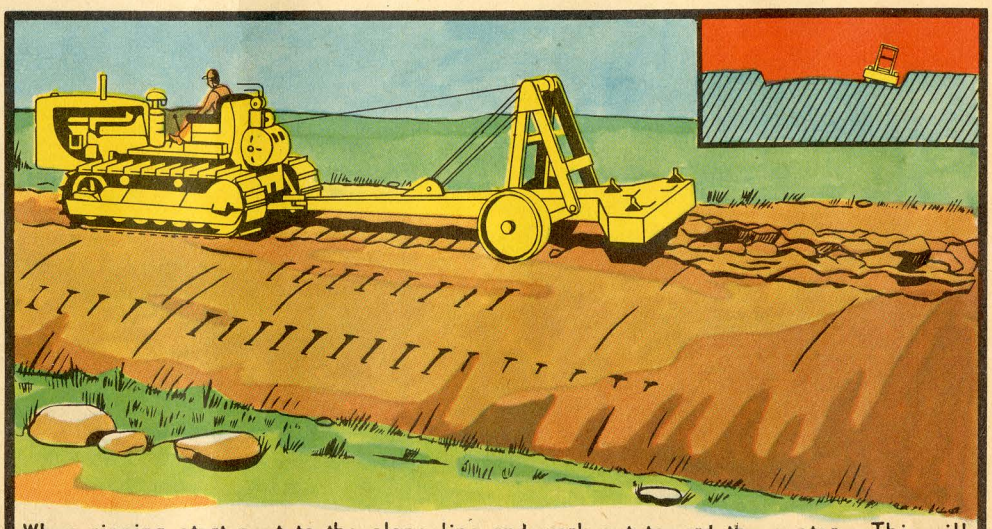




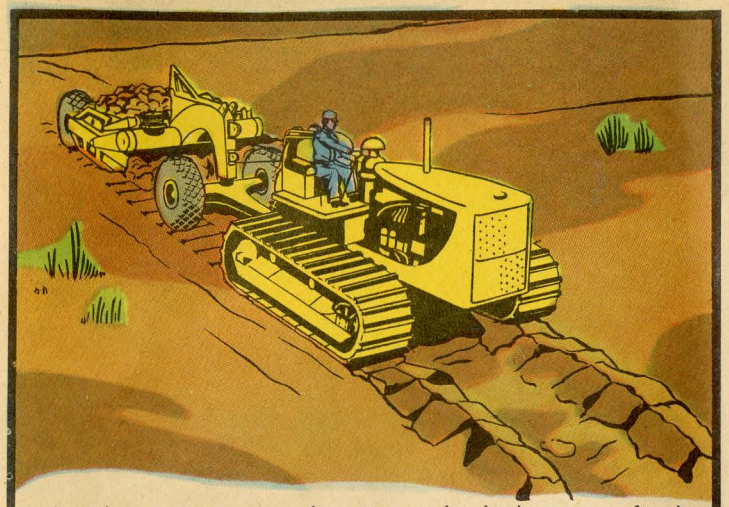
Only a single cable is needed to operate the ripper and control the depth of penetration of its three removable teeth.



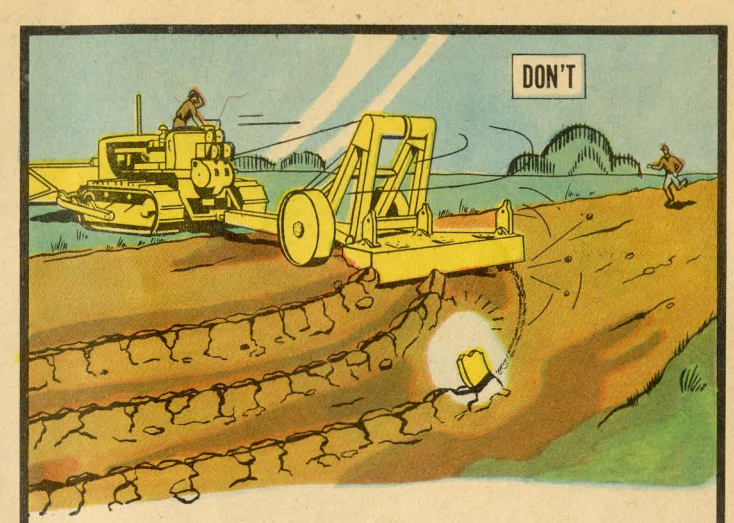
Rippers are used to break up shale, hardpan, cemented gravel and other materials so that they can be loaded or bulldozed.



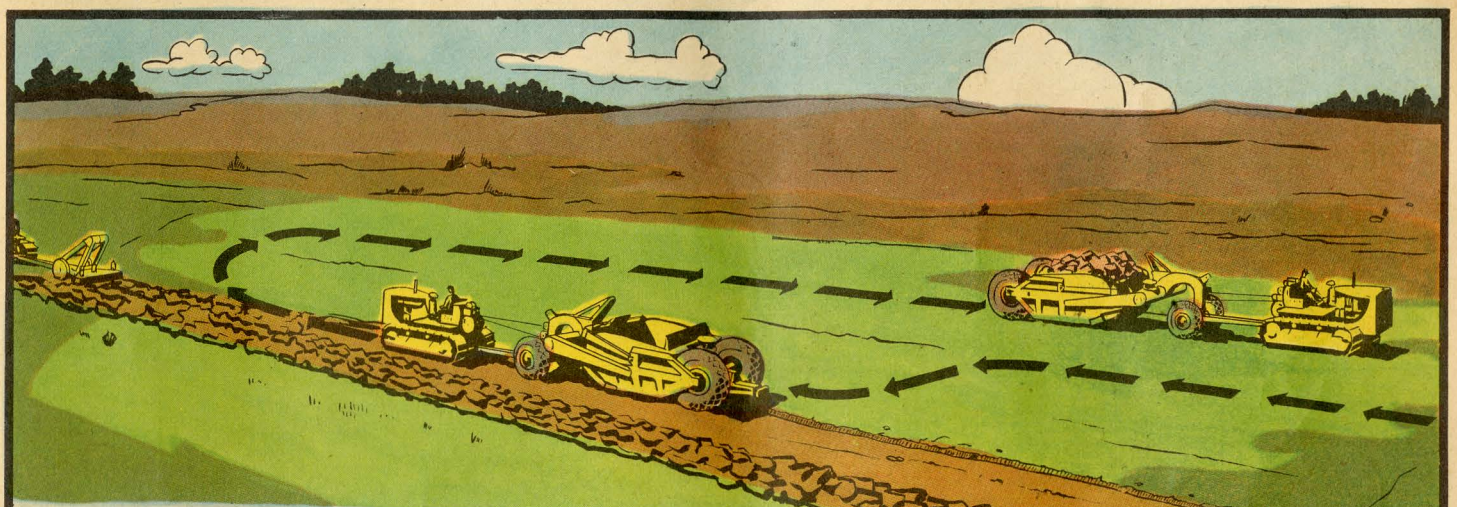
When ripping start next to the slope line and work out toward the center. This will help keep the cut low on the sides and crowned in the middle when scrapers start to work.



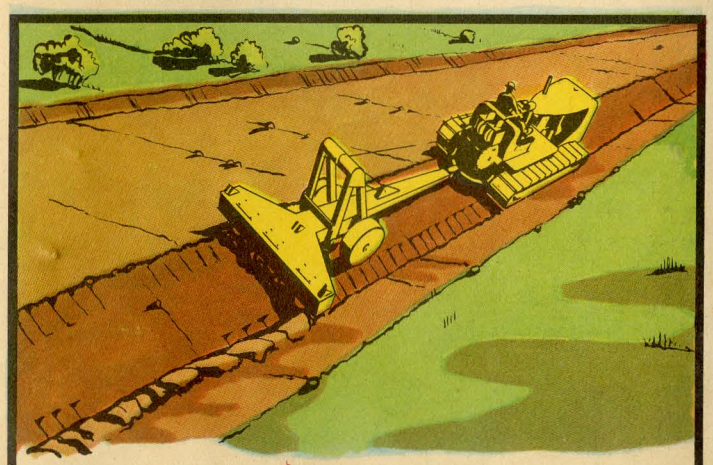
Avoid ripping too much. Material which is too finely broken is often harder to load than chunky material. Ripping with two teeth in wet clay tends to dry it out and make easier loading.



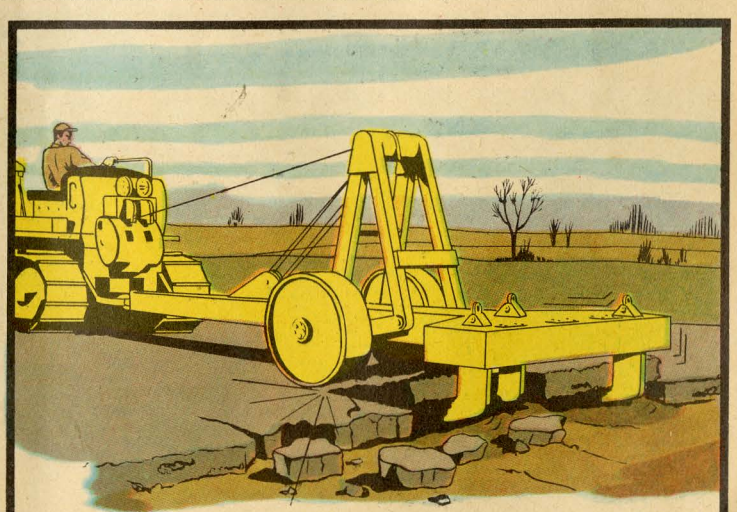
To prevent bending or breaking teeth, never turn while they are in the ground.



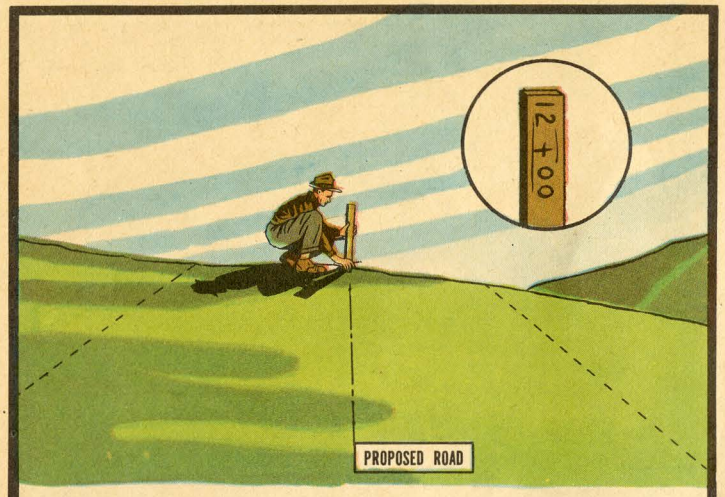
Plan work to avoid congestion and interference with other equipment on the job. Scrapers should be routed to travel on the unbroken section.



When using only one tooth it should usually be the center one. However, when constructing a side ditch, install one tooth in the outside bracket and work carefully to avoid ripping where it is not desired.

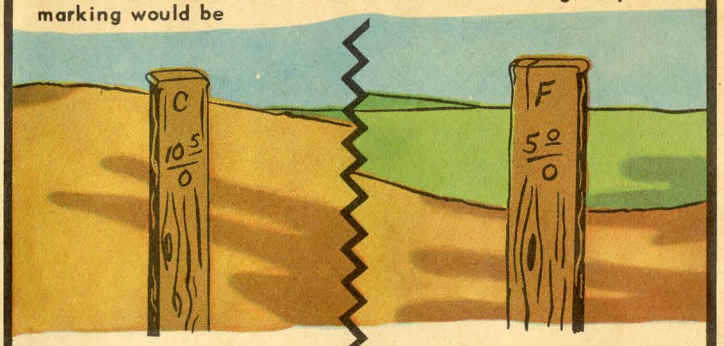


When ripping concrete, the best practice is to stop and hook the center tooth under the edge of the slab, and then raise and lower the ripper to crack the slab. Asphalt, and black top can usually be ripped as the tractor travels forward.



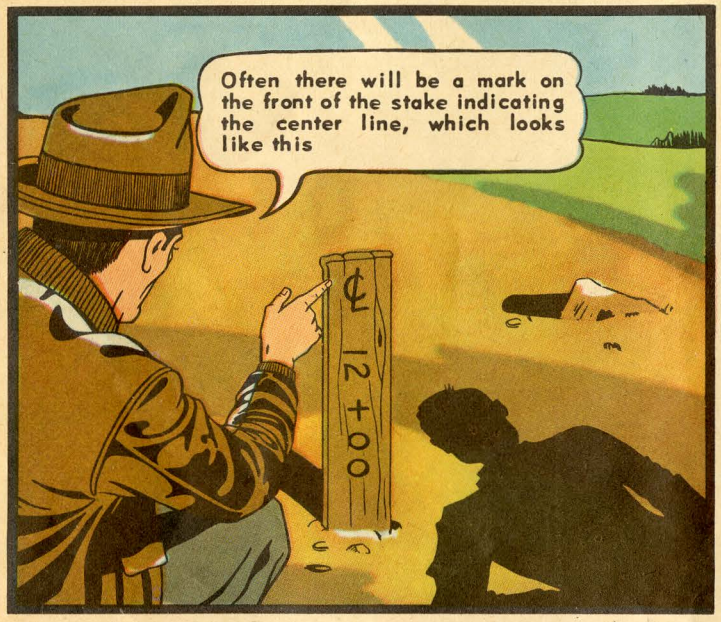
The center line stake faces the starting point and is marked with the distance from zero. For instance, the stake 1200 feet from the beginning would be marked 12 + 00. This would indicate 12 full stations of 100 feet each.

On the reverse or back side of this center stake is placed the distance to the grade. A cut is marked "C", a fill "F". With 10½ feet to remove on center to grade, the marking would be

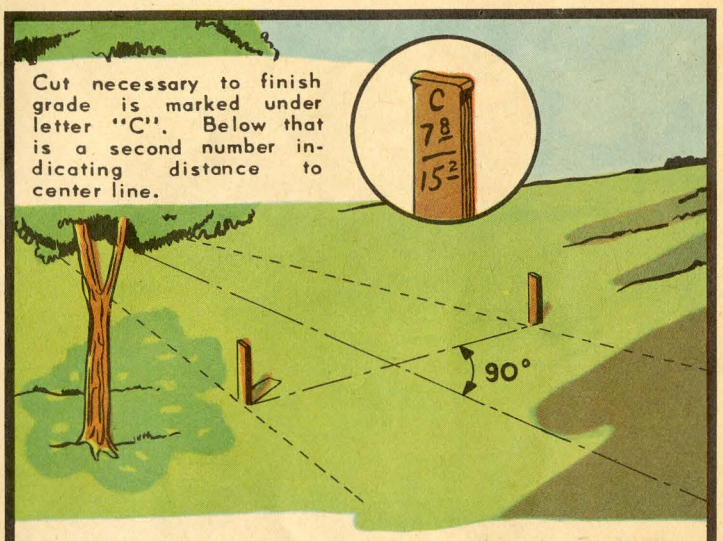


The top figure shows the amount in feet and tenths of a foot. The zero indicates the stake is on center line.

A fill of 5 feet would be marked

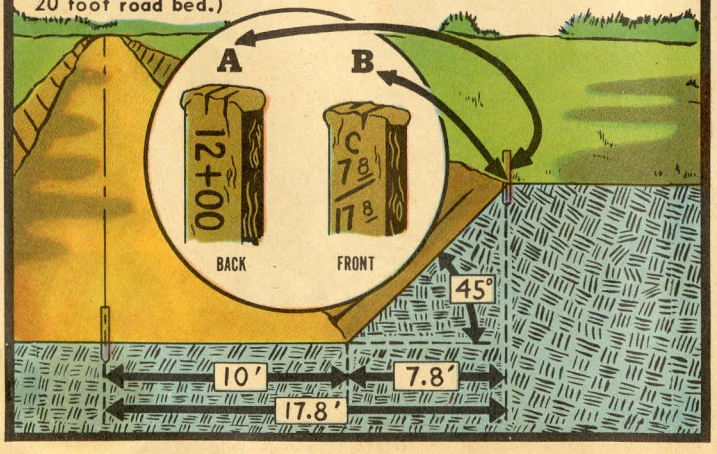


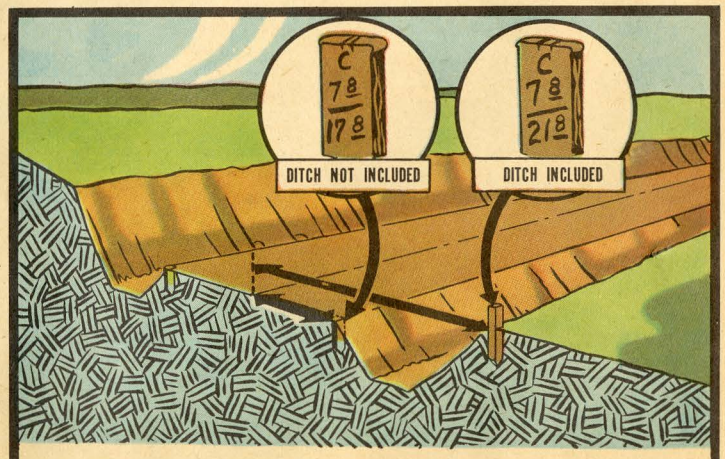
Cut necessary to finish grade is marked under letter "C". Below that is a second number indicating distance to center line.



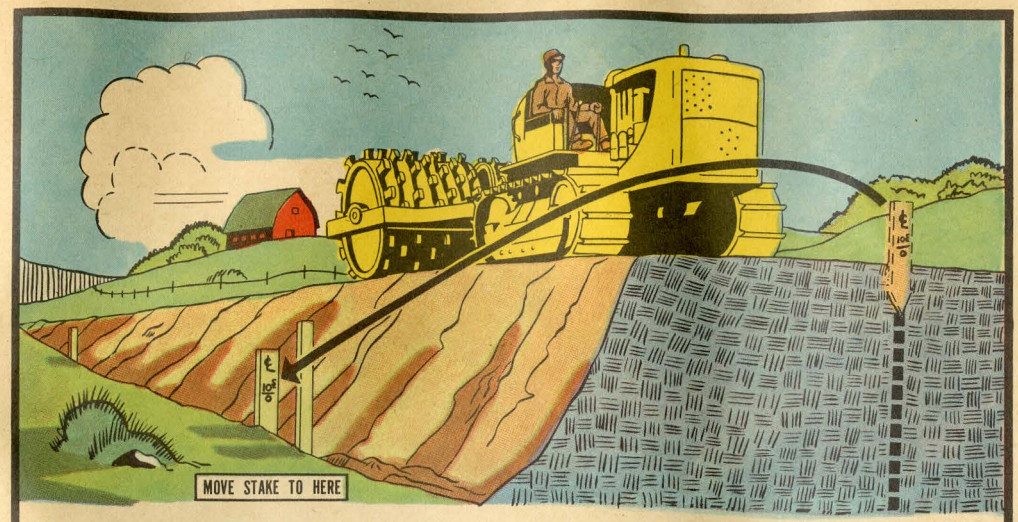
Cut or fill stakes are placed at right angles to the center line and face toward the center.

A 1 to 1 slope (45°) means for each foot of cut you move out one foot. Thus a cut at station 12 + 00 would be marked on the back like (A) . . . and on the front side facing the road markings would look like this (B) (if a 7.8 foot cut was indicated.) (The 17.8 feet marking is the distance from outer line of road to the cut stake assuming a 20 foot road bed.)

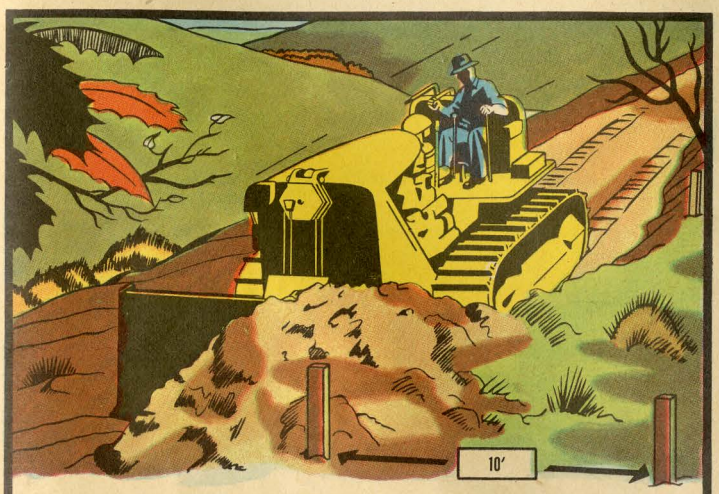




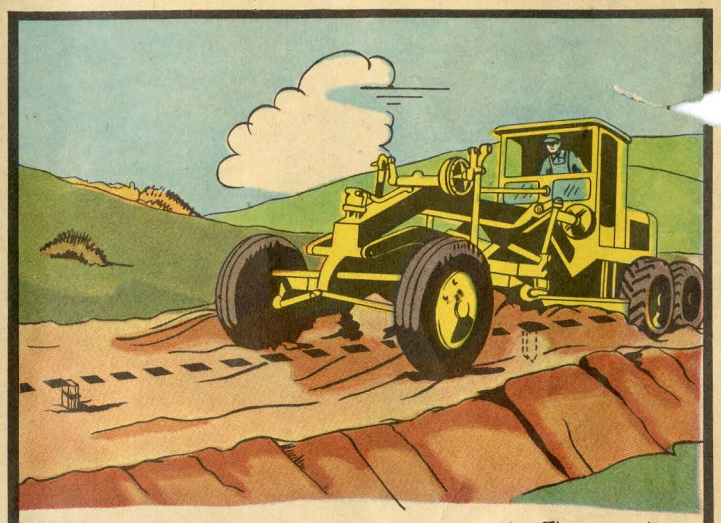
If ditches are to be included in the cut, the top width of the ditch must be included in the distance marking on the front of the cut stake.



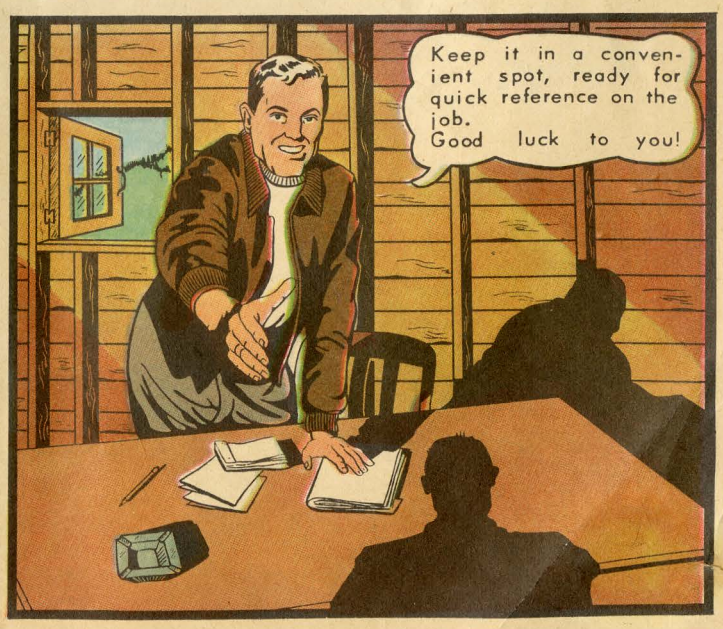
The centerline stake is useless as soon as work is done on center of cut or fill. It should be removed and driven into ground near one of the outside stakes to preserve it for reference.



Sometimes additional reference stakes are set ten feet out from cut and fill stakes so that information on slope stakes will not be lost if a tractor runs over them.



When finishing, blue topped stakes are used. These stakes are driven into the grade until the blue top of stake is flush with proposed finished grade.



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